

Georgia Institute of Technology
STATE ENGINEERING EXPERIMENT STATION
Atlanta, Georgia

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FINAL REPORT

PROJECT NO. 177-120

SURVEY OF THE NEEDS OF INDUSTRY
FOR
RAW MATERIALS FROM NEW PLANTS
TO BE
GROWN IN THE UNITED STATES

By

H. H. SINEATH
P. M. DAUGHERTY and T. A. WASTLER, JR.

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CONTRACT NO. A-1S-33022

DIVISION OF PLANT EXPLORATION AND INTRODUCTION
BUREAU OF PLANT INDUSTRY
UNITED STATES DEPARTMENT OF AGRICULTURE

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MARCH 1, 1952

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I. ABSTRACT

This report summarizes the results of a survey to determine the needs of industry in the United States for raw materials from plant sources. The project was instigated by C. O. Erlanson, Head of the Division of Plant Exploration and Introduction, Bureau of Plant Industry, United States Department of Agriculture.

The survey was divided into three phases: a literature survey, contacts with national associations and research organizations, and contacts with industrial companies. The background information, the method of attack, and the survey statistics are presented for each phase. The detailed information obtained was summarized in phase reports and copies of these are the Appendix of this report.

Based on these results, conclusions have been drawn, and recommendations for future work have been made.

II. INTRODUCTION

Through the Research and Marketing Act of 1946, the Bureau of Plant Industry activated in 1947 a national program for the introduction and investigation of new plants of potential value to United States agriculture. Plants which might be utilized by chemical and manufacturing industries were given special emphasis, since a diversification of crops might place agriculture in this country in a better economic position. The Georgia Institute of Technology was requested to make a survey of the needs of industry for raw materials from plant sources by C. O. Erlanson, Head of the Division of Plant Exploration and Introduction. The purpose of the survey was to present a more comprehensive picture of the raw material needs of industry which could be

used as a guide in the search for plants of potential economic value.

The primary objectives of the survey were:

1. A review of the literature to determine the recognized needs which have been published.

2. Direct contacts with industry to get first-hand information of industrial raw material needs.

3. After needs have been established, determining

- a. How much is needed,

- b. The price that could be expected for the material, and

- c. The effect of price on the volume needed for use.

The program designed to accomplish the stated objectives was as follows:

1. Literature Survey, compiling the needs which have been published.

2. Contacts through industrial associations.

- a. Correspondence with, and visits to, executive secretaries of groups such as American Drug Manufacturers Association, Plastic Materials Manufacturers Association, etc., relative to needs.

- b. Attendance of meetings of cooperating groups to contact leaders.

- c. Listing of best companies for detailed contacts from recommendations from a and b.

3. Contacts with research institutes, universities doing industrial research, and government laboratories.

- a. Correspondence.

- b. Visits to discuss needs that have been recognized.

4. Organization of general information obtained in 2 and 3 in order to select obviously promising leads with chances of early results.

5. Visits to outstanding companies in each industry, with special attention to leads from 4.

a. Talks with technical men concerning recognized needs.

b. Talks with sales development groups concerning possible new products from new plants.

6. Summary of findings in a report, including recommendations for additional work.

III. PROCEDURE

A review of the literature was conducted to determine recognized or published needs for raw materials from plant sources. A secondary object was to locate published information indicating new crops that might have economic value.

Fifteen periodicals were selected from a list compiled of publications that were likely to contain pertinent information. A general scanning survey was made which covered the period from January, 1946, through December, 1951. Numerous needs and various potential sources for raw materials were revealed.

A detailed discussion of this work was presented in Phase Report No. 2 which is included herein as Appendix I.

Correspondence was directed to 253 organizations which are included in the four general categories listed in items 2 and 3 of the project program. (These categories are national industrial associations, university research organizations, research institutes, and government laboratories.) Answers were received from 153 organizations; this represents a 60 per cent reply to all correspondence. The answers led to personal interviews with representatives of 20 organizations. The break-down by type of organization is given in Table I. From all

contacts, both written and personal, 67 needs and 47 industrial contacts were suggested.

TABLE I.
SURVEY STATISTICS

<u>Organizations</u>	<u>Total Number Contacts</u>	<u>Total Number Answers</u>	<u>Number Personal Interviews</u>
National Associations	96	52	10
University and Research Institutes	144	90	7
Government Laboratories	13	11	3
Totals	253	153	20

In accordance with item 4 of the program, the results obtained from the contacts with organizations in the four categories listed above were summarized in Phase Report No. 1 which is included as Appendix II.

After reviewing the information presented in Phase Report No. 1, the 47 companies recommended for contact were classified in one of the following groups according to the raw material they use:

1. Oils
2. Fibers
3. Drugs and Pharmaceuticals
4. Waxes, Gums, and Resins
5. Miscellaneous Materials

Also classified in these groups were 711 additional companies which were selected on the basis of their use of raw materials which have been reported as needs. Individual letters were written to all 758 of these

companies; answers were received from 454. Personal interviews were conducted with representatives of 37 companies. From both written and personal contacts, 189 raw material needs were suggested. Forty-nine of these needs were considered significant and were discussed in Phase Report No. 3 (Appendix III.). Volume and price statistics were compiled when available and estimates were given of the volume needed and price per unit that could be expected.

In addition to these needs, 23 potential raw material sources were suggested. Thirteen companies offered their services as evaluation agencies for new material disclosed in their general field of interest.

This report summarizes information obtained from the entire survey. The detailed results of this work are given in the Phase Reports which comprise the Appendix.

IV. CONCLUSIONS AND RECOMMENDATIONS

After reviewing the results of the entire survey, it is believed that the methods employed were satisfactory for obtaining the desired information. Personal contacts were particularly valuable, since individuals gave detailed information verbally that they declined to disclose by correspondence.

The survey has indicated that there are widespread shortages of, or needs for, many plant raw materials necessary to industry. These were classified into the following general categories:

1. Oils
2. Fibers
3. Drugs and Pharmaceuticals
4. Waxes, Gums, and Resins
5. Miscellaneous Materials

Most of the items listed have been classified as needs because of supply deficits or because of prices which are incompatible with the present price structure. Domestic sources have been recommended for some items because of other undesirable conditions. These detrimental factors include adulteration or contamination of imported materials, speculation on world markets, and the control of supplies at the source by the producing countries.

Among the most critical needs of oils are drying oils of the tung and perilla types and essential oils such as citronella and lemon-grass. A desire has also been expressed for domestic sources of, or substitutes for, other oils such as lauric acid-containing oils and sperm oil. Several fibers were reported as being needed. Among these are jute, "harsh" cotton, cordage fibers, and raw materials for paper manufacturing, such as bamboo. Included in the drug and pharmaceutical needs are ergot, menthol, atropine, and cortisone. Supplies of carnauba, candelilla and other hard waxes, many water soluble gums, vegetable resins and rubber latex are insufficient. Some other materials for which need has been expressed are alcohols, cellulose derivatives, glycerine, black pepper, pyrethrum, and tannins. Several plants were suggested which may have potential value as sources or replacements for some of these items that are short at this time.

It is recommended that future work include an extension of the literature survey to cover past and current publications. This investigation should delve further into the past literature than was possible under contract A-1S-33022, and the information obtained should be summarized at appropriate intervals.

Since it is believed that more information on the growth, cultivation, industrial applications, and the present and future economics of several specific raw materials would be of value, it is recommended that market surveys, including bibliographical reviews, be conducted on specific items which are of interest to the Sponsor.

The survey has revealed enough information to permit considering some raw material items for detailed study. Among these are

Chia or perilla oils,
sesame oil,
Simmondsia,
bamboo,
kenaf,
khellin, (Ammi visnaga)
candelilla wax, and
pyrethrum.

Chia and perilla oils have been selected for consideration because representatives of industrial concerns have said that there is a need and that there would be a good demand for a drying oil of their type. A survey of either of these oils might lead to using these oil sources for crop diversification in the United States.

Sesame oil has been included in the interest of expanding domestic edible oil sources. Research has indicated that the yields per acre of sesame oil are relatively large as compared to those from other sources. This oil is easy to refine and does not become rancid rapidly during storage.

Simmondsia or jojoba oil has been suggested as a direct replacement for sperm whale oil. The speculative nature of obtaining sperm oil has

resulted in considerable interest by industry in the possibility of developing a plant source for a suitable substitute. The volume potential for Simmondsia oil has been established at 45,000 tons per year, based upon the current needs and the amount that would be required for newly developed uses.

Bamboo has been included as a possible answer to the need expressed by industry for a domestic source of long cellulose fiber which would produce several times more fiber per acre, annually, than present sources. This plant is suggested since the Bureau of Plant Industry is already interested in certain types of bamboo (presently being investigated) which might fill this need. Bamboo pulp has been successfully used for manufacturing a variety of papers in India. This plant also has the advantage of having various other established uses.

Kenaf has been selected because this plant provides a fiber suitable for sacking and various types of cordage. This fiber is one of the most promising substitutes for much-needed jute, which must be imported from distant sources. Some promising results have been obtained from test plantings of kenaf in various regions of the United States.

Khellin, which is extracted from the fruit of Ammi visnaga, has been included since it has been estimated that the retail market for khellin preparations could be increased tenfold from the present market value of five million dollars per year. Foreign control of the source of khellin, in limiting the amounts available, has restricted research on new uses for the drug and on secondary constituents of Ammi visnaga.

Candelilla wax is one of the most suitable substitutes for scarce and high-priced carnauba wax. A representative of the wax industry has expressed the opinion that the industry is generally interested in a

domestic source of this wax, primarily to ensure stable purity and price. Candelilla-producing plants grow in the semi-arid regions of southwestern United States and could provide a paying crop for that area.

Pyrethrum supplies have been far smaller than the amounts needed by insecticide manufacturers. Although allethrin producers feel that they will be able to take care of a good portion of the pyrethrum demands by 1953, there is reason to believe that production of pyrethrum in the United States might be worthwhile..

If the results obtained from the pursuance of the market and literature surveys are satisfactory, bulletins should be published for distribution to selected organizations.

Respectfully submitted:

H. H. Sineath,
Assistant Project Director

Phillip M. Daugherty,
Research Assistant

T. A. Wastler, Jr.,
Research Assistant

Approved:

Herschel H. Cudd,
Project Director

Gerald A. Rosselot, Director
State Engineering Experiment Station

V. APPENDIX

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- II. Phase Report No. 1
- III. Phase Report No. 3

Georgia Institute of Technology
STATE ENGINEERING EXPERIMENT STATION
Atlanta, Georgia

PHASE REPORT NO. 2

PROJECT NO. 177-120

SURVEY OF THE NEEDS OF INDUSTRY
FOR
RAW MATERIALS FROM NEW PLANTS
TO BE
GROWN IN THE UNITED STATES
LITERATURE SURVEY

By

H. H. SINEATH
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JANUARY 18, 1952

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This Report Contains 114 Pages

I. SUMMARY

This report presents the results of a literature survey to determine the needs of industry in the United States for raw materials from plant sources. The project was initiated by C. O. Erlanson, Head of the Division of Plant Exploration and Introduction, Bureau of Plant Industry, United States Department of Agriculture.

Periodicals carefully selected for their comprehensive coverage of their particular fields were subjected to a page-by-page scanning, and the published shortages and possible substitutes were recorded. These periodicals were examined for the period January 1, 1946, through December 31, 1951.

The needs and substitutes reported were classified for discussion into the following categories:

1. Fats and Oils
2. Fibers and Wood Products
3. Drugs and Pharmaceuticals
4. Waxes, Gums, and Resins
5. Miscellaneous Materials

The most critical needs were for drying oils, some essential oils, hard fibers, pulpwood, hog bristles, ergot, atropine, cortisone, menthol, hard waxes, some water soluble gums, rubber latex, alcohols, cellulose derivatives, glycerine, black pepper, pyrethrum, and tannins.

Continuation of the literature survey is recommended with elimination of those periodicals that yielded little information not duplicated in others.

II. INTRODUCTION

A review of the literature was undertaken as a part of the program initiated at Georgia Institute of Technology by C. O. Erlanson, Head of the Division of Plant Exploration and Introduction, Bureau of Plant Industry, United States Department of Agriculture, to determine the recognized or published needs for raw materials from plant sources. A secondary object was to locate published information indicating new crops that might have economic value.

III. PROCEDURE

The survey of the periodicals was carried out in the following manner. The pertinent sections of Ulrich's Periodical Directory, Postwar Edition, were reviewed, page by page, and a list of all publications which were thought likely to contain useful information was compiled. Seventy-seven of the magazines on this list were found in the Georgia Tech library. One or more current issues of each of the available magazines were scrutinized and classified in one of five classes, ranging from "no help" to "exceptionally helpful." The top two classifications ("exceptionally" and "very" helpful) contained 16 periodicals, including at least one from every pertinent category. Economic Botany was added to the list and it was possible to eliminate some references as the survey progressed. The following 15 journals were finally selected as representative samples for careful examination:

- (1) American Paint Journal
- (2) American Perfumer and Essential Oil Review
- (3) Business Week

- (4) Canadian Journal of Research--Section C, Canadian Journal of Botany
- (5) Chemical and Engineering News
- (6) Chemical Engineering
- (7) Chemical Industries (Chemical Industries Week, Chemical Week)
- (8) Chemurgic Digest
- (9) Drug and Cosmetic Industry
- (10) Economic Botany
- (11) Oil, Paint and Drug Reporter
- (12) Paint, Oil and Chemical Review
- (13) Science News Letter
- (14) Textile Colorist and Converter
- (15) Textile Technology Digest

Several annotated lists of government publications of the various departments were reviewed for special reports and for serial publications. After studying the most promising publications, it was decided that the information contained in them would be duplicated in the periodicals listed above.

The complex nature of the material desired from the survey necessitated a page-by-page scanning with perusal of those sections or articles which were of interest. The periodicals were covered from January 1, 1946, or from the initial issue in cases where publication began after that date, through the last issue of 1951.

The Textile Colorist and Converter, which terminated with the last issue of 1948, was covered to that date. Chemurgic Digest was reviewed from the first issue of 1947.

The April through October, 1949, issues of Drug and Cosmetic Industry were not available for examination, nor was the April 14, 1949, issue of Paint, Oil and Chemical Review.

IV. CLASSIFICATION OF RESULTS

The disclosed needs were classified into these general categories:

- A. Fats and Oils
- B. Fibers and Wood Products
- C. Drugs and Pharmaceuticals
- D. Waxes, Gums, and Resins
- E. Miscellaneous Materials

Specific items from each of the above classifications that were considered to be of special interest, because of continued shortages or importance to industry, were screened for discussion. Unless otherwise stated, the data on imports were obtained from the United States Government Reports, Foreign Trade Statistics, Report No. FT-110.

V. DISCUSSION OF RESULTS

A. Fats and Oils

1. Drying Oils. In general, drying oil shortages were apparent throughout the period covered in the survey. Those oils for which the United States is mainly dependent upon foreign sources, such as tung, castor, perilla, and oiticica, were of course critically short during World War II; a similar situation exists now. Steps have been taken to improve conditions by domestic production of tung and castor oils in several southern states. Other oils that might be cultivated domestically to replace these have also been investigated to varying degrees.

a. Linseed Oil. This oil is by far the most widely used drying oil. Prior to 1947 the United States imported large quantities of both linseed oil and flaxseed from Argentina. Since then, the greater part of the oil used here has been produced domestically. This increased production can be attributed to excessive demand during the war, promotional efforts of the United States Department of Agriculture through price supports, and the import control law, which governed the importation of flaxseed and linseed oil. (3)

National consumption of linseed oil is approximately 600 million pounds annually, of which about 280 million pounds are necessary to supply the demand for the paint and varnish industries alone. (243, p. 4067).

The availability of linseed oil varies depending upon crop successes and the season of the year. A process that has been developed to obtain linen from ripened flax could increase the production of linseed oil somewhat by utilizing the same plant for linen and oil. (117)

b. Soybean Oil. Soybean oil is second only to linseed oil in the volume used for drying oil purposes. Seasonal variations in the supply of this domestically produced oil are responsible for the shortages reported. Soybean oil is used mainly for edible products; a maximum 15 per cent of all that produced in this country finds its way into industrial applications (243, p. 4066). The amount used for drying oil purposes had been increasing at a steady rate until 1950 when the demand for other applications skyrocketed the price to a point where it was not economically attractive as a drying oil (3). An increase in the production of other edible oils would play an important part in determining the industrial future of soybean oil.

A synthetic drying oil that uses soybean oil as a raw material has been marketed since 1948 in limited quantities by a California company (121). Several other synthetic drying oils developed from soybean oil have been reported. It has also been suggested as an extender for other drying oils. (76, 77, 251)

c. Tung Oil. Tung oil is an exceptionally fast drying oil that is particularly in demand for waterproof and spar varnishes. Supplies of tung oil have been insufficient to supply the needs, as this country has been almost entirely dependent upon foreign countries as the source. In order to reduce this dependence upon foreign supplies, cultivation has been started in the Gulf Coast area. As there is only a limited area in which the tung tree can survive due to susceptibility to freeze damage, only about 25 million pounds are produced. This is far below the volume that could be used if it were available.

Another major disadvantage to domestic production is the fact that the press cake contains a toxic compound and cannot be used for livestock feed. It is used as a fertilizer, however, and tests indicate that it might be used in combination with phenolic resins to produce plastics of good appearance and low water absorption. (243, p. 4067).

In view of the tung oil shortage, a substitute from Mexico, cacahuananche oil (Licania arborea), which is similar to oiticica, was suggested. (132)

d. Castor Oil. Although castor oil has various uses other than as a drying oil, it is discussed here. An increasing amount is being dehydrated for this purpose and the shortages disclosed by the search were from protective coatings industry journals.

The demand for dehydrated castor oil has increased during the last few years because of the difficulty in obtaining tung oil. The drying qualities of this oil are superior to those of linseed, comparing favorably with those of tung.

The most important areas of castor bean growth are Brazil, India, the Soviet Union, and Manchuria (243, p. 4067). Even though the demand has long exceeded available supplies, no extensive domestic production was undertaken until recent years since the seed tended to shatter. Thus, the plant did not lend itself to mechanical harvesting. The seed is also poisonous, thereby requiring special methods of handling the beans and meal residues and eliminating any value of the press cake for feed.

In the past few years researchers developed plants more adapted to modern methods and determined areas where these plants could be grown. This resulted in a vastly increased domestic production, mainly in Arizona, California, Oklahoma, and Texas (178). Since it has been established that a relatively stable market exists in the United States for a castor bean production of 200 million pounds (266, p. 45), and plans are for a crop of only approximately 78 million pounds (66, 67), it would appear that further expansion would be profitable.

e. Oiticica and Perilla Oils. The use of oiticica and perilla oils has declined until it is of minor importance (3). Both these oils, however, possess excellent drying qualities; oiticica oil resembles tung oil in that it contains conjugated unsaturation, and perilla oil is more like linseed oil in properties and structure.

Oiticica oil is obtained from the nuts of a tree that grows in a wide area of northern Brazil. Although production has begun to increase in recent years, the oil still cannot be obtained in the required quantities. (243, p. 4068)

Perilla oil is obtained from a plant several varieties of which grow in Manchuria, Japan, and northern India. Perilla shrubs that grow wild in Texas were found to be excellent potential sources of drying oils. (49, 149)

Domestic production of perilla is somewhat doubtful since the seed shatters badly when ripe, making harvesting difficult, and consistently good stands of perilla have proved hard to obtain. (243, p. 4068)

f. Safflower Oil. This is an oil which recently has attracted a great deal of attention in western United States. The oil is superior to soybean oil and almost as good as linseed oil in drying properties. It has been grown for many years in northern Africa and the Middle East on a relatively small scale but has seldom entered world trade. (171)

It has been established that methods of cultivation and harvesting the seed are comparable to those used for wheat (267), and that areas in Colorado, Wyoming, Nebraska, California, and Oregon are ideal for its growth (243, p. 4069). Plants that produce seeds of higher oil content have also been developed and yields per acre are high. The plant is not bothered seriously by insects or diseases. (111)

The residual meal provides a high protein livestock feed which has been shown to be fully equal to soybean meal of approximately the same crude protein content. (111)

g. Stillingia Oil. This oil could be used by the paint and varnish industries if it were more readily available. The oil is extracted from the kernel of the fruit from the Chinese tallownut tree,*

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* The Chinese tallownut tree, Sapium sebiferum, was at one time called Stillingia sebifera.

a native of Asia. This tree now grows in the United States from South Carolina to Florida, Louisiana, and Texas. It was introduced for ornamental purposes around 1900, and since then plantings have been made in Texas for experimental purposes.

The tree grows to a height of about thirty feet and produces fruit in three or four years. An average of 150-160 trees per acre yield about 1,200 pounds of a superior drying oil, comparable to tung, perilla, and oiticica, worth approximately two hundred dollars (149). The seed contains 20.3 per cent oil (53.4 per cent of the kernel is oil), 23.9 per cent tallow, and the extracted meat is 76.4 per cent protein. The tallow is edible, keeps well and can be made into candles of the non-running or self-consuming type that burn without unpleasant odors. The meal should serve well as a protein supplement for livestock. (233)

Commercial growing of the Chinese tallownut tree seems practical and feasible in the Gulf Coast regions of Texas, but there are two major difficulties. The nut contains a non-drying portion, the tallow, that must be completely removed in order to yield a high-grade drying oil. There has been reported, however, that a suitable extraction process using pentane and hexane has been developed (186). The cost of hand harvesting, which has been used, makes a commercial scale undertaking prohibitive; however, a nut-picking machine has been constructed that operates somewhat like a vacuum cleaner. Claims are that this machine will clean and sack 3,500 nuts a minute. (104)

The tree has these advantages; it is little affected by dry weather, insects do not bother it, and livestock will not eat the foliage.
(49, 120, 196)

h. Chia-Seed Oil. An oil derived from the mint Salvia hispanica is a good drying oil of the perilla type but it has not been produced commercially to any extent. Although the plant is native to Mexico and the southwestern United States, attempts to cultivate it in this country have not been successful. Possibly the plant might be adapted to production by ordinary methods, thus increasing its availability. (95, 137, 232)

i. Garcia nutans Oil. The pinchillo tree, Garcia nutans, which grows in eastern Mexico and Central America, produces a seed that contains 55 per cent oil. The oil is comparable to tung, and in some properties is even superior. There is no doubt it would be used if it were obtainable. Exploration trips through Mexico and Central America have not indicated that Garcia nutans is found in sufficient numbers to justify expectations of any substantial amounts of seed for crushing. Orderly grove plantings of trees has been suggested in order to build up a worthwhile source of oil. Test plantings have been made in Florida and Texas to determine the possibilities of the tree on plantations. (176, p. 122; 260)

j. Kamala Oil. The small black seeds of the kamala or rohini tree, which grows in India, Bengal, Bombay, Orissa, and Uttar Pradesh, yield a fatty oil that dries four times as rapidly as tung. The Forest Research Foundation of Dehra Dun, India, has been experimenting with kamala oil since 1940, but the high cost of extracting this oil has prohibited its use in paints and varnishes. This Institute has recently reported that a simple and relatively inexpensive extraction method has been worked out. (81; 133; 139; 243, p. 4070)

k. Makita Oil. This new seed oil recently reported from Australia seems to be promising. The tree grows throughout southeast Asia and the Fiji Islands. The kernel of the fruit called makita, or kusta, is 30 per cent oil. Both the iodine number (208) and the refractive index (1.543-1.561) indicate a high degree of unsaturation. The untreated oil dries to a frosty film, but, by polymerizing it at 232° C for two minutes, the oil dries clear. It dries faster than tung, and varnishes from linseed-makita mixtures are equal to linseed-tung varnishes in most respects and are superior in water resistance and film hardness. (63)

l. Lallemantia Oil. An oil similar to linseed may be recovered from the seeds of Lallemantia iberica which is native to Asia Minor, Armenia, and Iran. It is also cultivated in southern Russia and has been grown in Germany. The plant makes no special demands on soil or climate and yields more and heavier seeds than flax.

In properties this oil is related to Chia and perilla. It dries in a thin film to a tough, transparent, tack-free coating in 48 hours without driers. With driers the time is reduced to four hours.

The press cake is high in protein and might serve as a livestock feed, although no feeding tests were reported. (54)

m. Candlenut-Tree Oil. Sometimes referred to as lumbang oil, this is not a new oil but it seems that it has not received the attention it deserves. The composition and properties indicate it would make an excellent medium for all kinds of protective coatings.

The oil comes from the seed of a tree which is fairly common in the Philippines, Malaya, Madagascar, and the Fiji Islands. The seed contains 24 per cent oil on the basis of whole nut, or 62 per cent on the basis

of the kernel. Its fatty acids are chiefly linoleic and linolenic, which contain non-conjugating unsaturation. This is unique, as it is a member of the Aleurites family whose members normally yield oils of eleostearic acid. (61)

n. Queenroot Oil. An oil-bearing plant that could be grown as a row crop and harvested with a mechanical harvester is queenroot, or queen's-delight. The plant grows widely in the South and Southwest and yields a seed that is 30 per cent oil. The oil can be extracted by conventional methods and exhibits drying properties that might prove valuable. (149; 243, p. 4070)

The root contains oil, a resin, and a glucoside that might be a starting point for the synthesis of several important medicinal products.

Sebastiana ligustrina, a member of the same class, is even a richer source of oil, often containing up to 37 per cent. (149; 243, p. 4070)

o. Others. British scientists stated that a "very promising" substitute for linseed oil has been found in a weed, Carpidium conophorum, that grows in West Africa. Development work is reported as being in progress. (60)

Sunflower-seed oil and grapeseed oil were suggested as extenders for major drying oils, but both of these are more often thought of as edible oils. (62, 252)

Milkweed-seed oil, isano oil, rubber-seed oil, tobacco-seed oil, and poppy-seed oil were reported as potential drying oils or extenders but only limited discussion was encountered concerning them. (92; 166; 243, p. 4070)

Table I lists oils, sources, and some physical and chemical constants of the oils that have been discussed. The source of the data are the same

as those for the discussion, supplemented by data from these publications:

Lange, N.A., Handbook of Chemistry. Handbook Publishers, Inc., Sandusky, Ohio, 1946.

Remington, J.S., Drying Oils, Thinners and Varnishes. Leonard Hill, Ltd., London, 1946.

Bailey, A.E., Industrial Oil and Fat Products. Interscience Publishers, Inc., New York, 1951.

TABLE I
CONSTANTS OF OIL

<u>Oil or Source</u>	<u>Per Cent Oil in Seed or Nut</u>	<u>Index of Refraction (25°C)</u>	<u>Iodine Value</u>	<u>Saponifi- cation Value</u>	<u>Specific Gravity (15°C)</u>	<u>Acid Value</u>
1. Castor (dehydrated)	50	- -	141-157	190-194	0.930-0.936	1.8-17
2. Tung	15-20	1.515-1.520	163-171	189-197	0.939-0.948	2-6
3. Oiticica	55-62	1.504-1.578	140-179	187-193	0.969-0.971	2-8
4. Cacahuanche	- -	1.5163	153	187	- -	0.8
5. Lumbang or Candlenut	62 (kernel)	1.4760-1.4790	140-164	190-193	0.920-0.926	2-4
6. Linseed	32-43	1.4797-1.4802	173-202	188-195	0.930-0.938	1-3.5
7. Perilla	35-45	1.481-1.484	185-211	188-194	0.932-0.936	2-5
8. Safflower	30-35	1.4769	120-150	172-203	0.923-0.938	0.5-11.6
9. Soybean	18-21	1.4723-1.4756	124-143	189-193	0.922-0.928	0.5-4
10. Sunflower	22-32	1.4659-1.4721	120-136	188-194	0.919-0.926	3-7

(Continued)

TABLE I (Continued)

CONSTANTS OF OIL

<u>Oil or Source</u>	<u>Per Cent Oil in Seed or Nut</u>	<u>Index of Refraction (25°C)</u>	<u>Iodine Value</u>	<u>Saponifi- cation Value</u>	<u>Specific Gravity (15°C)</u>	<u>Acid Value</u>
11. Grapeseed	10-15	1.4713-1.4725	130-160	175-195	0.923-0.936	0.5-4
12. Rubber-Seed	21-25	1.4694	133-143	186-195	0.925-0.930	- -
13. Poppy-Seed	40-50	1.4739-1.4742	132-156	190-197	0.924-0.927	0.5-3
14. Stillingia	53.4 (kernel)	- -	Apx.200	211	0.943-0.945	3.1
15. Chia-Seed	28-36	1.4838 (20°)	195-199	195	0.936 (25°)	1.4
16. <u>Garcia nutans</u>	55	1.5252	177	- -	- -	- -
17. Kamala	- -	- -	- -	- -	- -	- -
18. Makita	30	1.543-1.561	203	194-196	- -	- -
19. <u>Carpidium conophorum</u>	- -	- -	- -	- -	- -	- -
20. Queen's Delight	30	- -	190	189	- -	- -

(Continued)

TABLE I (Continued)

CONSTANTS OF OIL

<u>Oil or Source</u>	<u>Per Cent Oil in Seed or Nut</u>	<u>Index of Refraction (25°C)</u>	<u>Iodine Value</u>	<u>Saponifi- cation Value</u>	<u>Specific Gravity (15°)</u>	<u>Acid Value</u>
21. <u>Sebastiana ligustrina</u>	37	--	191	205	--	--
22. Lallelantia	31	--	169-209	189	--	--
23. Milkweed-Seed	--	--	--	--	--	--
24. Isano	--	--	--	--	--	--
25. Tobacco-Seed	--	--	--	--	--	--

2. Essential Oils. The major portion of the essential oils used in the United States has been from foreign sources. One reason for this has been that the production of many of these oils requires extensive hand labor, the cost of which is prohibitive in this country. Another reason is that various plants from which essential oils are obtained require specific climatic conditions not found in the United States.

The reported shortages were due in part to the government's attempts to control inflationary tendencies by price ceilings. In some cases the price ceilings were set at a value below the price demanded at the source, or near enough to that price to make it economically impractical for dealers to import the items. The war also had the usual effects of shipping difficulties and decreases in production of these non-critical imported oils.

When World War II cut off about three-fourths of the supply, there was a considerable increase in domestic production (The value of domestic essential oils in 1946 was \$20,000,000 as compared to \$9,800,000 in 1939.) (36), and the move to establish an essential oil industry in sections of this hemisphere was promoted. Shortages, during and since the war, resulted in many imitations¹ being developed and used. Some of these were of such substantial merit that manufacturers continued to use them even after normal trade in the corresponding natural oils was resumed. (13)

There were about 70 essential oils reported as being in short supply at some time during the period covered by the survey. Of these some were only mentioned in the first years searched, only mentioned a

few times, or imported in relatively minor amounts. Such items will not be discussed. They are

oil of almonds,	oil of mandarin (tangerine oil),
oil of angelica,	musk ambrette,
oil of apricot kernel,	oil of neroli (oil of orange flowers),
oil of bay,	oil of nutmeg,
oil of birch tar,	oil of origanum,
bois de rose oil,	palmarosa oil,
oil of canella bark,	oil of patchouli,
cajuput oil,	oil of pennyroyal,
oil of cardamon,	oil of peppermint,
cedar-leaf oil,	oil of petitgrain,
cedar-wood oil,	<u>Pimenta</u> leaf oil,
oil of celery,	pine-needle oil,
oil of cypress leaf,	rosemary oil,
erigeron oil,	oil of sassafras,
oil of fennel,	oil of shiu ("Ho"),
oil of ginger,	oil of snakeroot,
oil of grapefruit,	oil of spearmint,
guaiacum-wood oil,	spruce oil,
oil of jasmine,	oil of thyme,
oil of juniper,	oil of turmeric,
oil of lavandin,	oil of wintergreen,
oil of mace,	oil of wormseed, and
	oil of wormwood.

Those essential oils found in short supply throughout the time period of the literature search are discussed, as are those oils that are used in large volume. Consideration also has been given to those oils for which supplies cannot meet the demands at the present times.

Dr. Ernest Guenther's volumes, The Essential Oils, were used extensively as a source of information concerning the oils discussed, (i.e., botanical nomenclature, plant habitat, uses, some comments on possible domestic production, etc.).

a. Oil of Anise. Actually there are two plants from which are obtained oils that are similar in chemical composition: Illicium verum, from which star anise oil is obtained, and Pimpinella anisum, which yields the more delicately flavored aniseed oil. The former is produced in French Indo-China and southern China. The latter, a native of the

Near East and Egypt, is cultivated in central, southern, and southeastern Europe, in southern U.S.S.R., Macedonia, Syria, Tunis, Morocco, India, China, Chile, and Mexico. It is also grown to a limited extent in parts of the United States.

Regions in the United States have been proposed as suitable for cultivating anise. These include areas in Ohio, Indiana, Kentucky, Alabama, Georgia, Missouri, Oklahoma, and Tennessee. (206)

In the past few years the United States has imported about 350,000 pounds annually, mainly from China and the U.S.S.R. The reports of shortages occurring in the literature of this same period indicate that more of this oil could be used if it were available. The uses of oil of anise include the flavoring of culinary preparations, beverages, confections, tooth pastes, and mouth washes, as well as its use for some medicinal formulations.

Recently an article has been published concerning work that has been under way at an experiment station in Java on the leaves of a shrub, Clausena anisata, which has been found to yield an essential oil high in anethol content. The material has an odor that differs from anise oil but it was believed that it could replace that oil for many uses. Experiments have also been carried out in Texas on the goldenrod plant as a commercial source of an essential oil. This oil resembles anise in odor and flavor and might prove to be a valuable substitute.

(6, 17, 196)

b. Oil of Bergamot. This oil is produced in a restricted coastal area in Calabria, Italy. The bergamot tree requires specific climatic and soil conditions, being easily damaged by frost and poorly drained soil. Attempts to grow this tree outside of Italy have generally

failed, but most of the trials were only half-hearted. This has probably been because of the difficulties in competing with the firmly established industry in Calabria, dominant by means of available cheap labor and long experience.

The United States imported about 130,000 pounds in 1950, and during this same year there were numerous references to the demand's being in excess of the amount supplied. However, in 1949, when imports amounted to 255,000 pounds, apparently there was sufficient oil to fill the need.

Oil of bergamot is one of the most important perfume scents and is widely used in lotions, creams, powders, and other toilet preparations.

Synthetic bergamot oil has been prepared from Ho (shiu) oil, which is produced only in Formosa.

c. Oil of Camphor. The main areas of production of camphor oil are China, Japan, and Formosa. Several species of the camphor tree, Cinnamomum camphora, Cinnamomum kanahirai, and Cinnamomum micranthum, are distilled in these areas for camphor and camphor oil. The entire tree, roots, trunk, branches, and leaves, can be used.

Recently this oil has been reported as being in short supply. This has probably been due to the fact that, in the past few years, most of the oil came to the United States from China, and trade with that country has been disrupted.

Prior to the last war the United States was dependent upon the Japanese monopoly for camphor oil products from their source in Formosa. In order that in the future we should not have to rely on imported material, the possibility of developing camphor trees in California has been considered (203, p. 23). Camphor itself is not the main concern, since whole camphor oil contains other fractions that make the growing of trees

in the United States worth considering. Excellent quality camphor can be prepared synthetically from pinene and from coal tar. Also, there are other natural sources of camphor and of safrole, one of the valuable components of camphor oil. Safrole is used in soaps and industrial perfumes and is the sole raw material from which the irreplaceable heliotropin is manufactured.

The annual import of camphor oil, including the fraction referred to commercially as "artificial sassafras oil", is approximately 600,000 to 800,000 pounds. Considering this and the annual imports of camphor, about 393,000 pounds in 1950, the value of investigating domestic cultivation of camphor trees is apparent.

A major disadvantage of introducing such a crop is the long growing period, as it would not be economical to harvest the trees before they are 15 years old. However, it has been estimated that an acre of camphor plantation would gross about \$157 per year. The cost of caring for the trees would be rather low but the cost of harvesting the crop would be relatively high due to the fact that the root, which contains the most safrole, would have to be dug. The pulp remaining after the oil has been distilled could possibly be used for the manufacturing of paper or wallboard although the fibers are short. (203, p. 26)

Ocimum kilimandscharicum, a perennial mint, family Labiatae, is being investigated as a source of camphor and camphor oil by Forest Research Institute, Dehra Dun, India. This plant has recently been introduced into the United States. It is a low growing herb that lends itself to mechanical cutting and harvesting and yields two or three cuttings a year. (18, 203, p. 26)

d. Oil of Cassia and Oil of Cinnamon Bark. The twigs and leaves of Cinnamomum cassia, which is cultivated chiefly in China proper, are distilled to yield oil of cassia. Oil of cinnamon is derived from the bark of Cinnamomum zeylanicum, a native of Ceylon. The cinnamon tree is also grown in other parts of the world, i.e., India, Mauritius, the Seychelles, and Jamaica. Ceylon furnishes most of the supplies of cinnamon bark for oil. In recent years the United States has imported cinnamon-leaf oil mainly from the Seychelles. The leaf oil consists mainly of eugenol and safrole.

Both cassia and cinnamon-bark oils were reported as being in short supply throughout the period included in the survey. Oil of cassia, which has a stronger and coarser odor, was apparently in the greater demand. This is probably due to the fact that oil of cassia costs about \$25.00 less per pound than cinnamon-bark oil. These oils are used in perfumery, flavoring, and medicine.

Since the main constituent of these two oils is cinnamaldehyde, work has been done on compounds similar in structure to develop cinnamon-like odors or flavors. Research has revealed several likely substitutes; the most promising was furanacrolein, which can be prepared in two steps from oat hulls. (21)

e. Oil of Citronella. Two closely related types of citronella grass are cultivated for distillation of the essential oil, Cymbopogon nardus, from which is derived the bulk of the Ceylon oil, and Cymbopogon winterianus, from which most of the Java oil is obtained. Ceylon is the sole producer of the first oil, and Java and Formosa are the main producers of the second. Lately Java oil has been commercially produced in Guatemala and Honduras, in Central America, and on the island of Haiti.

There has been no commercial domestic production of this oil but experimental cultivation in Florida and Puerto Rico has been conducted. The Department of Agriculture of Paraguay, in cooperation with essential oil distillers, has made plans to import stock to plant citronella in appropriate areas of that country (47).

It was stated that the production of citronella oil in this hemisphere has progressed to such a marked degree that should the international picture cause cessation of oil shipments from the Far East, it would be reasonable to assume that United States demands could be supplied (126).

Citronella oil was found to be fairly consistently in short supply throughout the period covered by the survey. It has been reported that the actual current requirement of this country for this oil is approximately 2,500,000 to 3,000,000 pounds annually (162). For the past three years an average of only 2,098,000 pounds of oil was imported.

The uses of this oil are widespread; for perfuming soaps, for insect sprays, in perfumes, for production of menthol, and for the manufacture of some important synthetic organic chemicals.

A substitute for oil of citronella has been reported that is derived from the leaves of Eucalyptus citriodora. The oil is easily distilled and contains 80-90 per cent citronellal. The harvest per acre is said to be double that of citronella grass. (22)

f. Oil of Clove. Commercial clove oil is obtained from the buds of the clove tree, Eugenia caryophyllata. The stems are also distilled to yield an oil that is inferior to the bud oil in odor and is not satisfactory for perfumes or flavors. However, this stem oil contains a high percentage of free eugenol and so is an excellent starting material for the isolation of eugenol, which is converted into

isoeugenol and an excellent grade of vanillin. In addition, some leaf oil is distilled in Madagascar, where topping of clove trees is practiced. This oil is hard to distinguish from stem oil and is used for the same purpose. Leaf and stem oils have been used as adulterants for bud oil.

Most of the oil came to the United States from Madagascar and Zanzibar. Both sources have been affected by difficulty in obtaining the necessary labor for harvesting the crops. The buds must be picked by hand at the proper stage of development since buds on the plant do not reach that stage at the same time. The trees have been bothered by a disease called "die back" which causes a gradual dessication of the whole upper part of the tree. Another disease, the so-called "sudden death", which affects older trees, has ruined whole plantations.

Clove oil (bud) is one of the most important essential oils, being practically indispensable for the flavoring of certain foods. It is also used as a flavoring in chewing gum, toothpaste, mouth washes, and for scenting toilet waters and soaps. Because it possesses antiseptic and bactericidal properties, many pharmaceutical preparations contain oil of clove.

g. Oil of Coriander. This oil is distilled from the seed obtained from Coriandum sativum, a plant native to southern Europe, Asia Minor, and the Caucasus. The principal producers of coriander seed are the U.S.S.R., Hungary, Poland, Romania, Czechoslovakia, Morocco, and more recently Guatemala, Mexico, and the United States. The seed offered for sale on world markets originates mainly from the U.S.S.R. In the past few years, the United States obtained the bulk of the seed that was imported from Argentina. Imports of oil of coriander were not listed but the seed imported averaged about 2,200,000 pounds annually.

Supplies of this oil were reported as insufficient during the entire period surveyed, but there were no statements as to the actual requirements.

This oil is used for flavoring food products, as a pickling agent, in tobacco products, gins and cordials. After the essential oil has been extracted, there remains in the seed a fat which can be used in the soap and textile industries. The remains of the seed can then be used as a cattle feed since it contains protein to the extent of 11-17 per cent. (264)

h. Oil of Dill. Although dill oil was reported as being in short supply at times during the period included in the survey, this country produces the oil in large quantities. In fact, the United States has become totally independent of former European sources.

The obvious answer to a shortage of dill oil would be increased planting, but in all probability the shortages mentioned were due to planning crops so as to maintain a price that would permit continued operations.

i. Oils of Eucalyptus. These oils are obtained from a variety of evergreen trees of the genus Eucalyptus, typically Australian, although some species are from New Guinea, Timor, and the Philippines. Extensive plantations in Africa, California, India, New Zealand, Spain, South America, and the Belgian Congo were planted with seed from Australia.

Oil of eucalyptus, which was reported as being in short supply at times throughout the survey period and especially in 1951, is imported mainly from Australia, Spain, and Portugal. The imports of oil from various plant species have amounted to over 500,000 pounds annually.

The oils find uses in medicine, perfumery, disinfectants, deodorants, as an industrial solvent, and as sources for manufacturing some chemicals such as thymol and menthol (from the pipertone present in large amounts in some eucalyptus oils).

During World War II, producers in the Western Hemisphere were able to supply the United States with eucalyptus oil because of the high prices which prevailed then. When Australian oil was again available, the future of these sources was made rather insecure. Eucalyptus trees that are already growing in southern and central California do not appear to be a practical source of commercial oil because the trees there are very tall, making leaf harvesting difficult and expensive.

j. Oil of Geranium. Commercial "oil of geranium" is a misnomer since the oil is obtained from several species, varieties, and strains of Pelargonium and not from any Geranium.

This oil was first produced commercially in the Grasse region of southern France, and from there the plants were introduced into the Reunion Islands, where quantities of geranium oil originate today. This oil has also been produced in Spain, Corsica, and Madagascar. Morocco and the Belgian Congo are becoming heavy producers of commercial geranium oil. Efforts to grow Pelargonium in the United States have been unsuccessful so far, mainly because the plant is very easily damaged by frost.

The oil is contained in the green parts of the plant, particularly in the leaves, and is obtained by distilling the overground plant material exclusive of the woody stalks. Part of the crop produced in southern France is extracted with volatile solvents rather than being steam distilled. This process yields a waxy solid mass of dark green material known as concrete of geranium, from which is obtained the alcohol-soluble

absolute of geranium. Both the absolute and the concrete have a very fine geranium odor that is softer and much longer lasting than that of distilled oil.

Oil of geranium is one of the most important perfume oils, and being stable in a mild alkaline medium, it is used widely to scent soaps. Supplies of this oil were found to be insufficient to meet the demand throughout the years covered by the survey. During this same period the United States imported about 55,000 pounds annually. No reference as to the quantity that might be used, if more were available, was encountered.

k. Oil of Lavender. This popular essential oil has been produced almost exclusively in southern France from varieties of Lavendula officinalis. Less important producing areas are in Italy, South Russia, Hungary, England, Australia, and the United States (Puget Sound). The oil produced in France is of much better quality than the others.

The plant grows wild in France, but it has also been cultivated. The oil is obtained by rapid steam distillation of the flowering tops and stalks. Since the plant tends to grow with the stalks bending down near the ground, French producers have never succeeded in constructing machinery to harvest the lavender.

Plantings in the Puget Sound region of Washington have done well. Since hand cutting of the crop is expensive and unsatisfactory in the United States, several experimental harvesters have been tried with some success. Work has also been carried out to develop plant strains of higher oil content. The odor of American oil is, in general, very good, although not quite as fine as that of the French product.

Oil of lavender, which in recent years the United States imported in quantities of approximately 400,000 pounds annually, is used in toilet waters and perfumes, and for scenting soaps. Lately, many soap manufacturers have been replacing lavender oil with lower costing lavandin oil, and this is considered one of the main reasons for the decreased production of the former.

Although shortages of this oil were noted throughout the time included in the survey, they were rather scattered and there was no indication that much larger volumes would be required.

l. Oil of Spike Lavender. This oil is similar to but is harsher than true lavender oil. It is produced mainly in Spain where the plant Lavendula latifolia grows wild in ample quantities. Spike lavender oil also was reported as being in short supply only at scattered times during the survey. It represents a low-priced lavender oil and is used for scenting soaps, for room sprays, disinfectants, etc.

m. Oil of Lemon, Lime and Orange. These citrus oils, which are contained in the peel of the fruit, are produced in relatively large volumes as by-products from the processing of the fruits for juice. All have been produced in the United States, mainly in California and Florida, in major amounts. Large quantities of these oils are also imported from other citrus growing areas of the world.

The oils are widely used for flavoring food products, particularly candies and soft drinks.

The survey revealed that supplies of these oils were insufficient in 1951, although previously there had been ample quantities available. An indication of the reason for this shortage was found in an article which stated that a large number of the frozen juice producers in

Florida were installing a new type of machine to process citrus fruit. The fruit is crushed in such a manner that it is no longer possible to produce the oil economically. The peel will be used for cattle feed at a greater profit. (4)

It is apparent, then, that to eliminate this cause of decreased oil production, attention should be directed to the type of processing machinery used, rather than to increasing citrus fruit production.

n. Oil of Lemon-Grass. This oil, which is one of the most important essential oils, is of two principal types: the East Indian oil from the plant Cymbopogon flexuosus and the West Indian oil from Cymbopogon citratus. Because of the high citral content (75-85 per cent), large quantities of lemon-grass oil are used for the isolation of this component. Citral is the starting material from which the important ionones are prepared. The ionones are a series of aromatic compounds that possess a powerful violet odor and are widely used in perfumes and perfumed products. Lemon-grass oil is also used for scenting inexpensive soaps and as a flavoring agent.

The East Indian oil is produced only in the southwestern part of India, the Malabar Coast area; the West Indian type is produced in large quantities in Guatemala, Haiti, Brazil, Madagascar, and Indo-China. Recently experimental plantings have been made in Florida, Puerto Rico, Mexico, and Paraguay. (36, 47, 126, 201)

Production in Florida flourished for a time because of the high price per pound (\$4.00) paid in the early years of World War II for lemon-grass oil. The utilization of the spent grass, mixed with molasses, as a feed to fatten cattle actually made the oil a by-product. When the price dropped to about \$1.00 per pound after the war, production in

Florida was abandoned. Since the price has risen recently, the growing of lemon-grass might again be profitable in the United States.

Prior to World War II imports into the United States amounted to 370,000 pounds annually (201). In recent years (1948-1950) imports amounted to about 570,000 pounds annually, which indicates the increasing importance of this oil. Shortages of supplies were indicated throughout 1951, probably due to increased use of this oil. Recently the ionones have served as the starting material for the preparation of some important synthetic organic chemicals, especially for the synthesis of vitamin A (56).

o. Oil of Ocotea Cymbarum. This oil, distilled from the wood of the Brazilian sassafras tree, was utilized as a source of safrole when the last war cut off imports of camphor oil to the United States. The wood of the tree contains about 0.5 per cent oil of which 85 per cent is safrole. This slow-growing tree is found in natural stands in Brazil, and as yet no attempt has been made to grow it on a plantation basis. Although Ocotea cymbarum oil was reported as being in short supply in 1951, it is estimated that there are sufficient trees near transportation to supply the world with safrole for 10-15 years. (203, p. 26)

Brazilian sassafras oil replaces camphor oil fraction in many technical preparations such as soaps, sprays, disinfectants, and deodorants. It cannot replace North American official sassafras oil, as the latter is distilled from a different plant, Sassafras albidum.

p. Oil of Roses. Supplies of this oil, obtained by the distillation of various roses, were found to be insufficient to meet the demand throughout the years covered by this survey. Most of the oil imported into the United States came from Bulgaria, U.S.S.R., and France

and amounted to about 33,000 pounds in 1950. The oil is used for perfumes, perfumed products, and as a flavoring agent.

Some work has been done in Texas on the extraction of oil from roses, but reports of other domestic production was not encountered (36).

q. Oil of Sage. The true Dalmatian sage, Salvia officinalis, grows on the barren, rocky, and sunny hillsides of the Dalmatian Island and adjacent coast of the Adriatic Sea. Large quantities of sage are used as such, but recently increasing amounts are being distilled for the oil. Both are used for flavoring sauces, foods, and meats. The oil has the advantage of being less bulky and more uniform than the leaves, since the leaves are not always dried evenly. Sage oil is also used as a convulsant, resembling wormwood in its action.

When World War II cut off the supply of sage and oil from Dalmatia, efforts were made to cultivate the true sage in the United States. Although many attempts failed to produce an herb of odor and flavor comparable to the Dalmatian product, some growers have succeeded in growing an excellent quality sage. Since the cost of growing sage in this country is high, most of that produced is used as the dried leaves, only a relatively small amount being distilled for the oil.

Sage grows well in regions from Wisconsin south to central Georgia and throughout eastern coastal states. Areas in Washington and California, where soil conditions and climate are similar to those of Dalmatia, are the main producing regions of domestic sage; the necessary hand labor is provided by Mexican laborers.

It appears that domestic sage production would be practical as a cash crop for American farmers if the necessary hand labor could be obtained. (The nature of this crop makes complete mechanical harvesting

unlikely.) The amount that is consumed annually in this country is about 1,500,000 pounds; in addition, the equivalent of 500,000 to 600,000 pounds of sage could be used as oil. (188, Vol. III, p. 722)

r. Oil of Sandalwood. This oil was reported as being in insufficient supply at times throughout the period covered by the survey, although the reports were scattered. There are three main sources, East Indian oil from Santalum album, West Indian oil from Amyris balsamifera, and West Australian oil from Santalum spicatum. The supply of Amyris balsamifera is not limited and so production in Haiti could be increased considerably if demand and price would warrant it.

The oil is used as a perfume fixative and for scenting cosmetics.

s. Oil of Vetiver. This oil was, in the past, obtained from Java, and root material of vetiver grass, Vetiveria zizanioides, was imported from Java for distillation in the United States. Civil strife and warfare raging in the interior of Java have disrupted production and exports of the oil from this source.

Vetiver oil of excellent quality has been produced on Reunion Island. The oil has also been produced in Haiti and to a small extent in Mexico, Guatemala, Honduras, and Brazil.

The American vetiver oil industry came into being when World War II caused supplies from Java and the Reunion Islands to be discontinued and prices to rise. Some of these new plantations were started without proper consideration of the type soil needed and so resulted in low yields of oil. The potential production in the Western Hemisphere, however, is large and, in the event that the Java oil should continue to be unavailable, the oil could be produced profitably.

This oil, which was reported as being in short supply throughout the period covered by the survey, has in recent years been imported mainly from Haiti. The United States has received 30,000-40,000 pounds annually in recent years, but supplies have been reported as inadequate.

Oil of vetiver is a most valuable and important raw material of perfumers. It is widely used in perfumes, cosmetics, and soaps. It has a pleasant, strong odor and serves as a natural fixative in perfume compositions. The oil is also used for the isolation of the sesquiterpene alcohols and their acetates, which possess a smoother odor than the original oil and are also good perfume fixatives. The Haiti oil cannot always be substituted for the Java and Reunion oils in perfume formulas since it differs somewhat in composition.

t. Oil of Ylang Ylang (Oil of Cananga). Ylang ylang oil is obtained from the distillation of the flowers of Cananga odorata which grows throughout southern Asia. Production of this important essential oil in the past was confined almost entirely to the Philippines but since has become an important product of the French colonies in the Indian Ocean (Comores, Nossi-Bé, Madagascar, and Reunion) (70). No references were encountered concerning production of this oil in the United States.

Like most flower oils, considerable hand labor is required in the production of ylang ylang oil, and the distillation of the flowers requires considerable care.

This perfume oil was reported as being in short supply in the past two years. In 1950, imports amounted to about 49,000 pounds. Complete data for 1951 were not available at the time. The major part of the oil imported comes from France and Madagascar.

A synthetic oil, called Basicol Ylang Extra, has been developed that costs about one-half as much as the natural oil. It is reported to duplicate the basic odor and the characteristic overtones of scent of ylang ylang. Its use to stretch the available stock of natural oil was suggested (90, 106).

u. Synthetic Essential Oils. Of interest is the fact that some imitations of essential oils have remained in demand even when the natural product was available. Among these are imitations of cassia, coriander, nutmeg, and mace. The advantages over natural oils are ready availability, favorable cost, uniformity, and freedom from price fluctuation. Two other important scientifically correct reproductions, oil of black pepper and oil of cardamon, have been announced. (13, 90)

3. Other Oils. Oils excluded from either of the previous categories but mentioned in the literature as being in insufficient supply will be discussed here.

a. Coconut Oil. This oil, derived from Cocos nucifera, was reported as being in short supply only occasionally during the period covered by the survey. Supplies of coconut oil and copra are presently at a good level; however, the United States is dependent entirely upon foreign sources for these important items. (243, p. 4065)

This country consumes over 500,000,000 pounds of coconut oil annually. Because it is one of the richest common sources of lauric acid, containing 40-50 per cent, it serves as the starting material for its isolation. Coconut oil is also used in cooking fats, oleomargarine, soaps, Napalm, paints and varnishes, and other industrial products.

b. Palm Oil. The oil obtained from the kernels of the fruit of Elaeisis guineensis is another common source of lauric acid. The United States imports kernels for processing as well as the oil itself.

Palm kernels are principally produced in Africa, but some Central and South American palms have yielded kernel oil in commercial quantities. These include babassu (Orbignya speciosa), tucum (Astrocaryum tucuma), murmuru (Astrocaryum murmuru), ouricuri (Syagrus coronata), and cohune (Orbignya cohune). Cultivating African palms in Central America has been considered in order to provide a paying crop for areas where bananas will no longer grow. (147)

The fruit of the palm tree also yields an oil of considerable importance. The United States imported about 82 million pounds of this oil in 1949. In both 1950 (when imports amounted to only 56 million pounds) and 1951 palm oil supplies were insufficient.

The kernel oil finds the same uses as coconut oil, while the oil from the fruit pulp is used as a lubricant and in butter substitutes. About 7,000 tons of this oil are used annually as a flux in tin plating. A processed tallow has been reported which can successfully replace palm oil for this purpose but which costs considerably less. (102, 131, 135)

c. Olive Oil. The United States is the only country that produces any quantity of olive oil other than the principal producers, the Mediterranean countries. However, the output in this country is small in comparison to the domestic demand, and since the main producing countries consume the major part of the oil they produce, the supplies here have been unable to meet requirements (243, p. 4068). The United States usually produces about four to six million pounds annually (Production has never exceeded 12 million pounds.), but consumption in recent years has been up to 76.5 million pounds of edible oil annually.

This oil is obtained by pressing it from the fruit of Olea europaea and has a characteristic odor and flavor. The oil, unlike most food

oils, requires no processing other than extraction from the fruit, clarification by filtering or settling, and packaging. The inedible oil obtained by solvent extraction of the press cake is used in soap manufacturing and for other industrial purposes.

d. Rapeseed Oil. This oil, from a number of species of the Brassica family, was reported as being in insufficient supply in the last two years covered by the survey. This oil is cultivated mainly in China, India, and Europe. It has been planted in Canada, Argentina, and Mexico. The oil is used as an edible oil, in lubricating compositions, in soaps, and as a quenching oil in tempering steel.

e. Tall Oil. This liquid resinous by-product of the sulphite process, containing a mixture of rosin acids and non-conjugating fatty acids, was found to be in short supply at times throughout the period of the survey. This oil is used to make metal tallates which serve as dryers for protective coatings. Since it is a by-product, it probably cannot be produced in any largely increased quantity. (130; 213, p. 66).

f. Cottonseed Oil, Corn Oil, and Peanut Oil. Supplies of these food oils have also been found to be inadequate. Of these, peanut oil seemed to be most plentiful, and cottonseed oil most critical. The disproportionate lack of the latter has been caused by restricted cotton planting in favor of food crops throughout the world during the war years. Shortages of the other food oils were partially due to this decreased production of cotton, since the demand for them was increased by the lack of cottonseed oil supplies.

Corn oil production is virtually limited to the United States and is a by-product of cornstarch and grain alcohol manufacture. It is derived from the germ of the seed.

g. Sesame Oil. The oil derived from the plant Sesamum indicum may become one of the more valuable oils of this country if the difficulties of its growth and harvesting can be overcome. Among other difficulties, shattering occurs when the seeds mature. An improved semi-shattering species has been developed by the Texas Research Foundation which, if harvested at the proper time, allows an 80 per cent recovery of the potential yield. One plant from this type was found that possessed non-shattering qualities and additional plants are being grown with the seed from this one. (3)

At the present time the main areas of production are India, China, Burma, Mexico, and Turkey. Minor areas include Africa, the Soviet Union, Manchuria, Iran, Greece, Pakistan, Nicaragua, and Columbia. Since exports from these countries have been reduced considerably in recent years, more emphasis has been placed on possible domestic production.

Sesame seed yields a relatively large amount of oil (400-456 pounds per acre of land) as compared to other seeds. The seed is readily processed in conventional oil mills, and the oil is easy to refine. The oil does not become rancid rapidly in storage, and its hydrogenated form has a high stability as compared with other oils. The press cake provides a high-protein livestock feed high in niacin and methionine content. (3, 182)

h. Sunflower-Seed Oil. Another edible oil that is becoming increasingly important is that from sunflower seed. This oil was obtained from the Soviet Union and the Balkans prior to World War II. Argentina has recently become the main source of this oil for international trade. Favorable growth as an oilseed source has been reported in Canada. California, North Dakota, and New Mexico are also

areas in which sunflowers are grown for seed. Sunflower-seed oil is used to improve the drying qualities of soy oil as well as for various edible purposes. (3, 125)

i. Okra-Seed Oil. The production of oil from okra seed had been impractical because the seed pods shattered badly during harvesting. Since non-shattering plants have been developed which produce seed in large enough yield to be profitable, this source appears to be worthy of further attention. The seed has been processed in gins and mills ordinarily used for cottonseed with only minor modifications of the equipment. (3, 238)

j. Rice Bran Oil. The oil is obtained by solvent extraction of rice bran with hexane in two Houston mills. The combined production will probably be less than 25 tons per day. There is a potential annual source of 30-40 million pounds of this oil, which is used for edible purposes and as a lubricating oil. This oil does not tend to become rancid and the extracted hulls provide a source of non-spoiling cattle feed. (3, 138, 208)

k. Squash-Seed Oil. A squash that promises to become a valuable source of vegetable oil has been developed. The squash reportedly yields up to 1,050 pounds of seed per acre which contain about 45 per cent oil. The press cake makes a concentrated high-protein livestock feed.

The squash grows well in any section of this country. Mechanical equipment needed for harvesting and extracting the oil has been developed. (50)

l. Lespedeza cuneata-Seed Oil. "Sericea", a plant that can be grown on sub-marginal land from Virginia to Kansas, yields seeds that

provide good cooking oil. The oil is unsaturated and is classed as a semi-drying oil. It has been reported that the stalks of the plant can be processed into a paper that could compete with wood pulp paper both in cost and quality. The potential utility of this oil is now being investigated. (57; 163; 243, p. 255)

m. Citrus-Seed Oil. Citrus seeds have been suggested as a vegetable oil source. The seeds would yield about a third of their weight in oil (89).

n. Sperm Oil. The need for an oil source to supplement the supplies of sperm whale oil could possibly be satisfied by a plant that grows in the deserts of western United States, Simmondsia. The seed of Simmondsia, or jojoba, yields a stable liquid wax similar to whale oil that might serve well as a replacement in many industrial uses. (179)

B. Fibers and Wood Products

Included in this section are the commercially important fibers and fiber products and all lumber and wood products which have been in short supply according to the periodicals examined in this literature survey.

Because of the tremendous variety of wood and fiber products used in this country, woods and fibers, as well as their processed derivatives, are imported from all over the world. Many such items are also produced domestically thus filling some requirements entirely, but in most cases domestic sources provide only a fraction of the needs of this country.

Fibers reported as being in short supply are abaca (Manila hemp), asbestos, bristles (hog), cotton and cotton products (bags, linters, duck, tie cord, webbing), flax, hehequen, jute, and sisal.

Shortages of hard and soft woods and certain wood products were reported. The latter are fiberboard, newsprint, paper board, paper products, pulpwood, and wood veneers.

1. Asbestos. This is used mainly as an insulating material but is also used in textile manufactures. Various asbestos manufactures are imported, as well as the crude material. Most imports are from Canada and Africa.

No substitutes or sources of supply have been reported in the literature surveyed.

2. Bristles (Hog). Hog bristles are used for many types of industrial brushes. Nylon and other synthetic materials have replaced hog bristles in many types of brushes, such as toothbrushes, hair brushes, etc.; but for paint brushes and similar products no satisfactory substitute for the natural bristle has been found.

China has supplied this country with nearly all of its bristles, and there does not appear to be another economically practical source available. Imports during recent years have amounted to about 7,000,000 pounds annually.

Research is being carried out to find a substitute suitable for paint brushes, but at present none has been found.

3. Cotton and Cotton Products. Cotton has been mentioned as being in short supply several times. Most of the shortages appear to be seasonal, but some of them are probably the result of increasing use of cotton as a substitute for other fibers in bagging and in cording (202, p.4).

The use of synthetic fibers as substitutes for cotton and wool in the textile industry is rapidly increasing (222); the development of protein fibers from corn and peanuts has been widely studied during

recent years. "Vicara" and "Ardil" have shown promise as blenders and substitutes. (142, 155, 228, 240)

4. Hard Fibers. The term "hard fibers" has been applied to the fibers of such tropical and sub-tropical plants as abaca, sisal, and henequen because of their characteristic harsh, coarse appearance and feel. The hard fibers are obtained from the leaves of perennial plants.

The main uses of the hard fibers are for cordage and for padding. They are ideal for these items since they are strong, light, durable, and non-matting. (202, pp. 43-44)

a. Abaca (Manilla Hemp). Abaca (Musa textilis) is the most important cordage fiber in the world, having displaced true hemp quickly after its introduction early in the last century. "Rope made from it is light, very strong, and highly resistant to salt water." (202, p. 44)

About 50,000 long tons of raw abaca were imported annually in the years after World War II; in addition, some 2,500,000 pounds of Manila cordage were imported annually during this period.

At the present, research on Manila hemp production is being carried out in Costa Rica (156), while at the same time, the search for substitutes is continuing.

Yawa, Vigna sinensis, a variety of the common cowpea, is cultivated in Nigeria as a source of fiber for ropes, twines, and fishing nets. The fiber has been reported to be a promising substitute for Manila hemp (129).

A promising substitute for abaca is sansevieria, often grown as a house plant. United States Navy tests show that this fiber has many of the same qualities as Manila hemp, and that it can be processed with the machinery used for processing abaca.

Sansevieria grows well in the frost-free areas of southern Florida. It responds well to fertilizer and the yields are good; estimated yields of the dry fiber run as high as 2,000 pounds per acre per year. The same type of equipment used for sisal and other leaf-fiber plants can be used in processing the plant. (242)

b. Henequen. Henequen, Agave fourcroydes, sometimes called "Mexican sisal," is a native of the Yucatan peninsula. Its fiber is somewhat lower in quality and cheaper than the African, Haitian, or Dutch East Indian sisal, but it is used for the same purposes. (202, p. 44)

Henequen is also grown in Cuba. Production in 1946 was estimated at 15,000 metric tons and was expected to be greater in 1947. The major part of this volume is used locally. (39)

Production of henequen has been declining since the war, because of a world preference for sisal (202, p. 5). If the quality of henequen fiber were improved to make it comparable with sisal, production of henequen could be expanded considerably (202, p. 21).

c. Sisal. Sisal products are second in importance to abaca as cordage fibers, but they are more important quantitatively. The habitat of the shrub (Agave sisalana) is in the Western Hemisphere, but the major production area for sisal is British East Africa. Haiti is the most important producer of sisal in the Western Hemisphere. (202, p. 44)

The sisal products are important as padding and filling materials and in making plastics. Sisal waste has been utilized for making certain chemicals such as pectins, pectates, hydroxy acids, saponins, glucosides, and fermentable sugars (108, 20).

Sisal production has expanded since the war and should continue to expand if prices remain high. Imports of sisal and henequen for the

post-war years amounted to about 100,000 long tons annually; of this, about half was henequen (202, p. 40).

"If hard fibers are not to continue in short supply, it will be necessary for the total world output of abaca, sisal, and henequen to be expanded by as much as 25 per cent above the 1950 output." However, no early end to the short supply situation is likely. (202, p. 19)

5. Soft Fibers. The "soft" vegetable fibers such as jute, flax, ramie, and true hemp are all yielded by the bast, or stem, of annual plants.

a. Flax. There are two types of flax. "Seed-flax" is grown primarily for its oil bearing seed and produces a fiber which is harsh and brittle and not suitable for spinning. "Fiber-flax" is grown primarily for its long spinnable fiber but produces seed as an important by-product. The fiber varieties grow taller than the seed type.

Consumption of flax fiber in the United States seems to have levelled off at about 60,000 tons per year, according to an estimate published in the latter part of 1949 (177). Large amounts of flax fiber and manufactures are imported, much from the United Kingdom. Russia, Poland, and the Baltic countries provide 85-90 per cent of the world's production. (183, p. 397)

Increasing amounts of fiber flax are being grown in this country and in Canada. In Canada, production for the 1946-47 season was estimated at 930 tons of graded scutched flax and 1,800 tons of tow. About 15,700 acres were grown. (39) In the United States, Oregon produces 98 per cent of the fiber flax grown domestically, which is a very small amount of the total world production. Much more flax could be grown in Washington and Oregon; there are 500,000 acres suitable for flax production in Oregon alone. (183, p. 397)

Improved varieties of flax, valuable for both linseed oil and fiber, have been introduced from several foreign sources. Their possibilities are now being investigated (170, p. 10). Efforts to use seed flax for linen manufacture have been most successful in the production of heavy yarns (217).

A new variety of flax developed by the United States Department of Agriculture was released in 1945. This plant, named "Cascade", is claimed to be tall, resistant to wilt, and immune from rust. (39)

The flax industry in this country received a temporary setback immediately after World War II when foreign sources of supply were again available and stockpiles were released. However, government price support measures stabilized the situation and the outlook is again good. (183, p. 404)

b. Jute and Burlap. Jute fiber is the most important fiber used for containers. All of the raw jute and most of the burlap consumed in the United States must be shipped from half-way around the world, mainly from India. About 800,000,000 pounds of jute have been imported annually from India in recent years (235). This has been used for cordage and bagging.

Supplies of jute have been tight since World War II because of decreased jute production due to re-emphasis on food supplies after the war and to the partition of India (1). A new trade agreement with India and Pakistan promises to provide larger supplies of jute in the future (202, p. 3). Greater utilization of jute waste may partially relieve shortages in some fields (51).

A considerable amount of work is being done to find substitutes for jute and other soft fibers. Much of this is being sponsored by the United States Department of Agriculture.

(1) Kenaf (Hibiscus cannabinus) is one of the most promising jute substitutes under development at the present time. Kenaf fiber has been used domestically in India for sacking, and has been exploited in Java under the name "Java-jute" as a fiber source for sugar sacking (171, p. 35). Pilot plantings of kenaf have been made in Cuba (154), El Salvador (53), and in various places in the United States, mainly in Florida, Texas, Indiana, and New Jersey (1, 83). Results showing some promise have been obtained. "In New Jersey a total yield, including root growth, of about 30 tons of green material was produced per acre in about 125 days." (1, p. 299) Seeds of several species introduced from northern China seem to be very well adapted to maturing in the short days of some areas of potential production (170, p. 10).

Problems facing the kenaf industry are the lack of a sure market and the difficulty of decortication. Government agencies are undertaking to provide a market for the limited acreage planted in 1951. It is estimated that yields will be about 1,500-2,344 pounds per acre (52).

Some progress is being made on the problem of decortication, although a satisfactory procedure has not yet been reported. A new French process for the decortication of ramie and other tropical fibers may offer some help. The lack of mill facilities in the Western Hemisphere for weaving bags from jute or kenaf is also a drawback. (52)

"Although kenaf appears to be adapted to wide variations in climatic and soil conditions, a well-drained, sandy loam soil, with a

considerable quantity of humus, appears to best meet the requirements of the plant. From 20 to 25 inches of rainfall over a period of four to five months is essential to the successful production of kenaf fiber."

(171, p. 348)

There is some disagreement as to how kenaf compares with jute. Some sources state that jute is more pliable than kenaf, and that sacks made of jute can be re-used more often than those made of kenaf fiber.

(52).

Kenaf fiber can be used for making gunny cloth or sacking material, ropes and cordage of all kinds, fishing nets, floor mattings, rug backing, etc. Kenaf seed yields up to 20 per cent by weight of an oil which can be refined for use as a cooking oil (171, p. 347).

(2) Ramie (Boehmeria nivea) is a perennial member of the nettle family, but it does not have the stinging hairs common among nettles. For successful growth it requires abundant moisture, fertile soil, and a semi-tropical climate (218). It can be grown almost anywhere within the latitude of 30° N and 30° S, so long as sufficient moisture is provided and suitable soil is available (256, p. 26, 27).

The fiber can be used as a substitute for many textile fibers and may make a place for itself as a textile fiber in its own right. Ramie fiber is superior to cotton and linen in tensile strength, having about eight times the strength of cotton; it has a tensile strength when wet which is 60 to 70 per cent greater than that when dry. This fiber can be combed to the fineness of silk; it takes dyes well and holds colors better than most other fabrics. (219) It is said that fabric can be made of ramie which would equal or out-perform linen fabrics in general wear resistance, and would compare favorably with linen in appearance.

Ramie is regarded as being especially suited for high-grade specialty fabrics. (172, p. 113)

Today ramie is growing commercially in China, Japan, Brazil, and the Philippines. Research on ramie is being carried out all over the world (27). It is now grown experimentally in the United States; the fiber grown domestically is believed to be superior to that which appears in international trade (170). About 3,000 acres were in cultivation in 1947 (218). The Florida Ramie Products Corporation has established a plant for the decortication of ramie at Belle Glade, Florida. This plant had an hourly output of 500 pounds of peeled fiber after two months of production. The fiber is being used by the Navy for packing warship propeller shafts. (39)

The main problems which have faced the ramie industry are the lack of efficient decortication methods and the difficulties of mechanical harvesting. Ramie plants growing in the same field and planted at the same time will often mature at different times. This has made mechanical harvesting difficult. Research in this country on cultivation and breeding has eliminated this difficulty to a great extent and mechanical harvesting has become practical (219, 27). The problems of mechanical decortication and degumming on a large scale still limit the commercial possibilities of ramie. (218, 219)

Ramie exhibits great potential possibilities in the textile field. It is unlikely that it will ever replace cotton to any large extent, (172, p. 111) but there are many other uses for it. This fiber can be spun, woven, or knitted on standard textile machinery and can be used alone or in combination with other fibers (218).

Other products besides fiber can be obtained from the ramie plant. Leaf meal, high in vitamin A and in protein content, can be made. This meal is highly suitable for cattle food. A ramie sauce for cooking has also been prepared. (256)

(3) Roselle (Hibiscus sabdariffa) yields a fiber which has the same chemical and physical properties as jute and, therefore, offers a very satisfactory substitute for jute. Roselle attracted considerable attention at the beginning of the second World War when the fiber was used for the manufacture of burlap and other fibrous materials. Roselle fiber may be employed in the manufacture of sacking material, ropes, and cordages of all kinds (174).

As roselle is sensitive to frost, sub-tropical or tropical locations seem best for cultivating the plant. A rainfall of 18 to 20 inches and long warm days are necessary during the three to four months period of major growth. The soil should be easily permeable and not subject to flooding.

It is believed that roselle can be processed in much the same manner as kenaf. The yield of dried fiber is from 1,000 to 2,000 pounds per acre, depending on environmental conditions and other factors.

(4) True hemp (Cannabis sativa) has been used in America since colonial times for twine, carpet thread, carpet yarns, sailcloth, homespun, yacht cordage, and oakum. Formerly much was grown in this country, but cheaper foreign labor resulted in increasing importations from Europe and Asia until the maximum importation of 50,000 tons was reached in 1889. Since that time competition from cotton and Manila has reduced American consumption of true hemp to a very small amount. In 1940 only two areas in Wisconsin and Kentucky were producing hemp (184). Consumption in that year amounted to 1,034 long tons (160, p.166).

When the supplies of Manila hemp were cut off at the beginning of World War II, attempts were made to revive domestic production of hemp fiber. Some success was achieved (62,803 long tons in 1943) but in 1945 all of the government-sponsored mills were closed down (160, p. 166; 184). Production is now very small.

Recent research relative to the retting and scutching of true hemp shows considerable promise for the future production of hemp fiber (160, p. 169)

(5) Posidonia australis, a marine plant found in abundance along the shore of South Australia, is said to be a possible substitute for jute. The fibers obtained from this plant closely resemble jute fibers, although they are somewhat shorter (2-8 inches). Other features of the fiber are its resistance to rot, comparative non-inflammability, and its ability to take acid dyes. It is useful for the manufacture of backings for oilcloths, linoleums, carpets and rugs, and for mixture with low-quality wool. The possibilities of this fiber are being investigated by Australian government agencies. (191)

6. Wood and Wood Products

a. Lumber. Shortages of almost all types of lumber were reported at different times. Some of these were needs for wood customarily imported, and there is very little that can be done about them. Insufficient supplies of domestic woods are being combatted by increased reforestation, especially in the South where the great stands of pine forest have become sadly depleted.

In the Douglas fir regions, 90 per cent of the areas now being logged are reproducing by natural means. The other 10 per cent are being reforested by seedling planting. (48)

b. Fiberboard. Several new developments in fiberboard manufacture have been reported in the literature. Douglas fir snags are being made into a hardwood-type board, called "Forest Hardboard" (226). Straw is being used to make box board for some uses (122). It is hoped that these will partially relieve the shortages of wood veneers and thin lumber (15). Straw has been used for corrugated strawboard in this country in the past (158).

c. Newsprint. Many pulps have recently been found promising for use in newsprint manufacture.

(1) Bagasse is the residue from sugar cane after the juice and sugar have been extracted. In the past it has been used in the manufacture of insulating and other boards but its use for other purposes has been limited because of difficulties entailed in separating the pith cells and fibers in the pulp (38). Recent research, however, indicates that there may be a practical method for separating the pith and fiber (10).

Methods of preparing newsprint from bagasse have been developed, and the product compares favorably with that now in commercial use (83). Plants which are to use bagasse for paper manufacture have been built in Mexico (224) and Brazil (72, 93). A process has recently been developed at Louisiana State University which converts about 27 per cent of raw bagasse to high-grade paper fiber. Pilot plant operations are now in progress (127).

Since about four million tons of bagasse are produced annually in Louisiana alone, the utilization of bagasse in the paper-manufacturing industry shows promise of relieving some of the drain upon forests for wood pulp (83).

Bagasse has also been mentioned as a possible livestock feed (124).

(2) Bamboo pulp has been used in India for 25 years for making a variety of papers. At present about 80,000 tons of such pulp are used annually for this purpose. (12)

Work is being done in this country to determine the possible use of bamboo for paper pulp in the United States. Tests show that this pulp will probably be very useful. Only a few varieties have been tested, but the results are very promising. One concern is contemplating the possible cultivation of bamboo in the United States for this purpose (11).

(3) Wheat straw has been used for newsprint manufacture by several concerns. The wheat straw product could be marketed at \$65-72 per ton in 1948 as compared to \$100.00 per ton for the commercial newsprint at that time (62).

A Uruguayan process for newsprint is reported to yield about one ton of newsprint from every two tons of wheat straw used (26).

(4) Several other newsprint sources have been reported at various times. Some of these are flax straw (168), mulberry wood (68), eucalyptus wood (37), Lespedeza cuneata (244), yuccas (176), and various American hardwoods (43, 114, 221, 231). Reports indicate that these will have little importance any time in the near future.

d. Wood Waste Utilization. Much progress has been made in utilizing wood wastes. Douglas fir waste has been used in many ways. Decayed wood has been converted into a sugar solution which could be used as a culture medium (211). Bark has provided several products useful in plastics compounding and as soil conditioners (157). Other Douglas fir

waste has been used to provide a livestock feed high in carbohydrate content (210).

Other wood wastes have provided cooking gas (28), synthetic humus (194), livestock feeds (151), and wallboards (198).

Since wood residues amount to about 109,000,000 tons annually, not including 27,500,000 tons of bark, the increased use of these residues could relieve many shortages (198).

Certain pulps not previously used have recently been found to be useful for rayon manufacture. Among these are eucalyptus (82), bamboo reeds, bagasse, and jute fibers (105, 153).

C. Drugs and Pharmaceuticals

The United States has been dependent in the past on foreign sources of supply for many botanical drugs. Many of the plants supplying these drugs can be grown in this country, but the cost of cultivation and harvesting is so great that it has been economically impractical to grow these plants in the United States. The main reason for this situation is that a great number of these plants require much hand labor for their cultivation and harvesting, and the cost of hand labor in this country is prohibitive.

During the first and second World Wars, when the foreign sources of supply of many botanicals were cut off, attempts were made to cultivate many of the plants in the United States. Some plants were successfully grown for commercial purposes during this period; but, when the foreign supplies were again available, many domestic producers were unable to compete economically, and production was discontinued.

Many of the shortages noted in the literature search were seasonal or were the result of shipping delays. Civil War or other internal

difficulties in the source countries have frequently resulted in a crop which is not medicinally acceptable. This situation has been noted to a large extent in the Middle Eastern and Far Eastern nations especially.

Botanicals cultivated in Communist-controlled districts are seldom available to the markets of the United States. Research has been done and is being done on many botanicals formerly acquired from these countries.

In some places the collection or cultivation of some botanicals has given way to other crops which bring a greater profit. Also, exports to the United States have decreased in some cases when better markets were available elsewhere.

Some items mentioned as being in short supply are not discussed for the following reasons:

1. Some items are of relatively minor importance as far as the over-all picture is concerned. That is, their function can be filled by other, more readily available botanicals or by synthetic materials.

2. The small volumes required of some of the minor drugs and pharmaceuticals make it impractical to consider them as long as substitutes can be found.

3. Seasonal shortages and shipping delays are the only shortages noted for some items; shortages of this type are to be expected.

The botanicals which have been mentioned as short but which will not be discussed for one or more of the foregoing reasons are

agaric,
aletris root,
black haw (Viburnum prunifolium),
bloodroot (Sanguinaria canadensis),
irisroot (blue flag root, Iris versicolor),
buchu,
burdock root,

Calabar leaves (Physostigma venenosum),
calamus,
cardamon seed,
catnip,
chamomile flowers (Anthemis nobilis and Matricaria chamomilla),
clover flowers
dandelion root (Taraxacum),
elder flowers (Sambucus),
galingale,
gentian root (Gentiana lutea),
grains of paradise (Amomum melegueta),
horehound,
jalap (Exogonium jalapa),
kamala,
kola nut,
Cypripedium (Lady's slipper root),
laurel leaves,
Lobelia,
mandrake root,
muskroot,
nux vomica,
passionflowers (Passiflora),
pine tar,
piperonal,
prickly ash berries (Zanthoxylum),
senega root,
St.-Ignatius's-bean (Strychnos ignatii), and
Valerian Belgian.

The drugs and pharmaceuticals in the following discussion have been selected for their continuing importance to the national health and welfare and their potential importance in the field of medicine. An effort has been made to include pertinent information, especially about those plants whose main sources of supply are not in the United States, or which have been critically short in past national emergencies.

The Merck Index, Fifth Edition, was used as the authority for determining the medicinal uses and habitats of the plants under consideration. Gray's Manual of Botany, Eighth Edition, and Webster's New International Dictionary, Unabridged, Second Edition, were used as guides for determining botanical names in cases in which the Merck Index gave incomplete information.

1. Aloes. The main source of supply of aloes is Curacao and the South African Cape. About 350,000 pounds have been imported annually since the end of World War II. The shortages noted are mostly the result of local conditions and are seasonal in character.

The material has a variety of uses, mainly as a cathartic in medicine and as an essential oil. Recently the announcement has been made that a new healing ointment, known as A-Gic has been made from the juice of the freshly picked Aloe vera plant. This ointment is said to be useful in treating burns of all kinds (44).

2. Aniseed. Anise is used in medicine as a carminative and industrially as a condiment and flavoring. About 1,000,000 pounds were imported annually in the period immediately after the second World War: most imports were from Turkey, Czechoslovakia, and Mexico. The habitat of anise is in Egypt and Western Asia, but it has been cultivated in southern Europe and the United States.

Recently it has been reported that anisatin, which may be useful as a heart stimulant, has been isolated from the Japanese star anise (98).

No new sources of supply have been mentioned in the literature surveyed.

3. Arnica Flowers. Arnica is used mainly externally as a lotion for bruises, sprains, etc.

Flowers of arnica were reported as being in short supply immediately following World War II, but shortages have not been reported recently.

Arnica flowers of the species most commonly used in medicine are not found naturally in the United States and are not believed to be practical for cultivation here. Some species, however, growing in the western part of the United States, are acceptable in medicine and have

been successfully collected. It is reported that the native plant is more satisfactory than the imported since the former has a higher resistance to disease and the product is cleaner. (268, p. 411) These native species probably could be an important source of supply if collection of the plant were encouraged.

4. Atropine and Belladonna. Atropine is the main alkaloid found in the roots and leaves of the plant Atropa belladonna, and the sulfate is used as an antispasmodic, antisialagogue, anhidrotic, mydriatic, cyclopegic, and respiratory stimulant.

The United States has been mainly dependent on foreign sources of supply for its stock of belladonna, but during World War II attempts were made by the United States Department of Agriculture to promote its cultivation in this country. Belladonna grows naturally in the northwestern United States (248), but it has not been grown commercially there. About 200,000 pounds were imported annually in the decade preceding World War II. The main source countries were Yugoslavia and Turkey.

During World War II extensive plantings of belladonna were made under the auspices of the United States Department of Agriculture in Pennsylvania, New Jersey, Ohio, Tennessee, Wisconsin, and Virginia. The best results were obtained in Pennsylvania and Wisconsin. The total amount of belladonna grown in 1942 in this country was 350,000 pounds (175, p. 62). Since then, the acreage has declined until by 1948 practically no belladonna was grown in the United States for commercial purposes. Attempts are now being made to adapt belladonna along with other botanicals, to the soil and climate of Arkansas. (97)

The technical knowledge for the cultivation of belladonna still exists, but the expensive hand cultivation required to grow, harvest,

and cure the crop limits the production of belladonna to times of emergency when the foreign sources of supply are cut off. (175, p. 63)

5. Camphor. Camphor is mainly imported from Japan, Formosa, Brazil, and other tropical countries. It is also made synthetically. Camphor is used rather extensively as a circulatory and respiratory stimulant, nerve sedative, carminative, antispasmodic, and for similar purposes. It is also used in the paint and varnish industry and in the production of many synthetics.

It has been reported that camphor basil (Ocimum kilimandscharium), native to Kenya, British East Africa, has been grown successfully as an annual in the Boston area. The plant has yielded 2.5 per cent of camphor similar to that obtained from Japan and China (17). Development of this product commercially has not been reported in the literature covered in this search.

The importance of camphor is such that an effort should be made to cultivate it commercially in the United States or to increase its synthetic production--perhaps to do both.

6. Cascara Sagrada. This plant provides a purgative which is widely used in commercial preparations.

Cascara sagrada is native to the northwestern United States. It grows wild on the rangelands of southeastern Oregon. This region could be a promising source of many crude drugs if the development of the industry were undertaken seriously. (248, p. 68)

7. Cinchona Bark. Cinchona bark is the primary source of quinine and its salts, quinidine, quinoline, and others of the same type. These are frequently used as antimalarials, astringents, and bitter tonics.

Cinchona is imported mainly from Indonesia and South America. Imports since the end of World War II have amounted to about 400,000 pounds annually.

The importance of cinchona bark has declined somewhat as a source of antimalarials with the development of synthetics such as atabrine. A synthetic antimalarial, "primaquine", has recently been reported. It is said to be four times as effective as its predecessors against recurrent malaria (85).

Latin American barks have been used chiefly for the production of "totaquine", a mixture of the useful alkaloids from cinchona (268, p. 412).

Cinchona requires a climate of a much more tropical nature than can be found in most parts of the United States; in addition, the extensive hand labor required would probably make it impractical as a commercial product in the United States.

8. Cortisone. Cortisone is a hormone originally prepared from an extract of cattle bile. It is regarded as useful for the treatment of rheumatoid arthritis, rheumatic fever, leukemia, asthma, ulcerative colitis, certain kidney diseases, gout, psoriasis associated with arthritis, Addison's disease, and lupus erythematosus. There may be other applications which have not been clearly defined as yet (64). As originally produced, the price of cortisone was in the neighborhood of \$150.00 per gram and required a long process.

Many organizations have been trying to find cheaper methods of synthesizing cortisone. Expeditions sent to Africa by the Merck Company, the United States Department of Agriculture, and the United States Public Health Service have been investigating the possibility of using an

African plant (Strophanthus sarmentosus) as a starting point for the synthesis (32). Soybeans and hellebore have been mentioned as starting points for a synthesis, as have certain members of the Agave and Dioscorea genera (101, 236). The Glidden Company has reported the isolation of several cortisone derivatives from soybeans, and also a process for cortisone which is less expensive than the cattle bile synthesis originally used (42, 227).

Recently (July, 1951) it has been reported that cortisone has been synthesized from the Mexican yam (Dioscorea paniculata or Cabeza de negra) by the Syntex Research Laboratories, a Mexican concern. The process requires twenty-two steps, but it is a practical process which will be used in an industrial plant expected to be in production in Mexico early in 1952 (34). It is predicted that, when this plant is in operation, the supply of cortisone will be doubled and that the price will fall somewhat from the present price of about \$35.00 per gram (33).

The work on cortisone has stimulated work in the entire steroid field, and some of the results seem very promising. The Mexican yam has yielded a new anti-arthritic known as "Artisone", which is of steroidal character and is cheaper than cortisone at present (119). Other hormones derived from this plant are being investigated (109).

Tomatidine, from the leaves of the tomato plant, has shown itself to be a source of pregnenolone, progesterone, testosterone, and possibly cortisone (116, 119). Pregnenolone has been used for the treatment of rheumatoid arthritis (7). A "total synthesis" of cholesterol has been reported, and it is predicted that cholesterol will be an eventual starting point for cortisone synthesis (46). Cholesterol is being produced from wool fat in a new plant at Ambler, Pennsylvania (257).

9. Digitalis. Digitalis is used mainly as a cardiac stimulant.

During peacetime, digitalis leaves are imported from southern and central Europe at the rate of about 50,000 pounds annually (between World War I and World War II). Small acreages were grown in some northern states during World War II (175, p. 65). At the present, digitalis is gathered in the foothills of Washington and Oregon. Domestic cultivation will probably continue, since the drug is adaptable to mechanized cultivation (268, p. 410; 248, p. 68). Work is also being done to make its cultivation practical in Arkansas (97).

10. Ergot. Ergot is a fungus or mold found on rye kernels and other grains. Only the rye ergot is medicinally acceptable at present.

Ergot provides several alkaloids which are useful in easing the pain of childbirth and in stopping hemorrhages, especially those resulting from childbirth.

About 200,000 pounds were imported annually in the years preceding World War II. Southern Europe was the main source of supply. During the war ergot was obtained in this country from rye kernels by a mechanical screening process. This process might be applied to a greater extent in order to provide a domestic source of ergot (175, p. 66). It has been mentioned that wheat ergots, in addition to rye ergots, might be used in medicine. Wheat ergots are apparently just as effective medicinally as rye ergots (259, p. 377). Work is being done by the College of the Ozarks to develop domestic sources of ergot (97). Some reports state that ergot can be cultivated in Oregon (248, p. 57).

The University of Florida has recently reported that a mushroom native to Florida and possessing many of the properties of ergot has been cultivated in their laboratories (87; 242, p. 18). Ergot alkaloids

such as ergotamine and ergonovine have been isolated from this mushroom (40). No data have been reported in the literature which would yield an estimate of the commercial value of this discovery.

11. Goldenseal Root. Goldenseal root is used as a hemostatic, anti-periodic, alternative, bitter tonic, and astringent.

It grows naturally in North America and is cultivated in several states (248, p. 68). It is possible that cultivation and collection of this botanical could be stimulated to such an extent that shortages could be greatly decreased.

12. Hellebore. Green hellebore, Veratrum viride, is used mainly as a cardiovascular and nerve sedative.

Its habitat is North America; the shortages seem to be either seasonal or the result of too little domestic collection.

Hellebore has been mentioned as a starting point for cortisone synthesis (25). Also, a new drug which is useful in treatment of high blood pressure has been discovered in green hellebore. This drug is named "germitrine" (14).

A new plant is in operation which is extracting veriloid (for high blood pressure) from hellebore (220).

13. Ipecac Root. Ipecac root provides nauseants and emetics.

It grows naturally in Brazil and Bolivia and is cultivated in India. About 45,000 pounds were imported annually in the years following World War II, mainly from Latin American countries. Recently ipecac has been scarce at the source because of local trouble with outlaws.

South American sources could probably satisfy the needs of the United States if a stable labor situation could be maintained.

14. Juniper Berries. Juniper berries yield a diuretic and urogenital irritant.

The berries are obtained from the tree, Juniperus communis, which grows in northern Europe, Asia, and North America. Imports come from Italy and Yugoslavia.

Work is being done to collect juniper berries commercially in Oregon (248, p. 68). The berries have been collected in Maine also. The crops compared favorably with those obtained from southern Europe. (268, p. 411)

15. Menthol. Menthol is widely used as an analgesic, antipruritic, and local antiseptic.

Imports in the years following World War II were largely from Brazil and China and amounted to about 400,000 pounds annually.

Mint oils are the primary source of menthol. Peppermint grows in nearly all parts of the United States but is too expensive to be a practical source of menthol. Work is being done to stimulate the commercial development of peppermint in Oregon (248, p. 68). The main difficulty at present seems to be the isolation of menthol from the botanical source.

A mountain mint (Pycnanthemum pilosum) native to the United States has been found to yield 200 pounds per acre of oil from which one-half its weight of menthol or thymol can be recovered. Investigation of the possibilities of cultivation is under way (99).

A Japanese mint is reported as being the only practical commercial source of menthol at present. It is known as "Japanese peppermint" or "Hakka-maru". Botanically it is a form of Mentha arvensis. The plant grows wild in nearly every part of Japan where there is wet ground from

Karafuto to Taiwan. The flavor of Japanese mint oil is inferior to that of the oil from peppermint, but the menthol content is higher. (270)

This plant has been introduced into the United States and grows well in many parts of the country. Southern California is the most suitable part of this country for the cultivation of Japanese mint, and it has been grown there during recent years. During the last war year virtually all of the menthol produced in the Western Hemisphere was produced in Brazil from plantings by Japanese immigrants.

While Japanese mint can be grown with profit in Japan and the Latin American countries and can be cultivated successfully in certain sections of this country, it does not seem to be economically feasible to produce menthol from this mint in the United States at present, owing to the prohibitive costs prevailing (270).

16. Papain. Papain is obtained from the juice of the fruit and leaves of Carica papaya.

Imports have amounted to about 400,000 pounds annually in the years following World War II, mainly from Ceylon and British East Africa.

Papain is used as a digestive aid. Recently it has been reported that papain powder has been developed for tenderizing meat in the home. (95)

17. Psyllium Seed (Plantago Seed). Blond psyllium seed, the most important type, is imported from India. About 3,000,000 pounds were imported annually in the years following World War II.

The husks of the seed are used in medicine as a mild laxative.

Experimental plantings in the western United States and Arizona are being undertaken. It will be several years before significant results are obtained. The yields thus far are reported as being low (650 pounds

per acre) compared to the Indian yields (1,500 pounds per acre) and the cost is relatively high. (204)

18. Rhubarb Root. Rhubarb root, used as a cathartic, bitter tonic, and stomachic, grows in central Asia. It is cultivated in Europe and southern Siberia and is imported mainly from India and China. Imports after World War II amounted to 100,000 to 400,000 pounds annually.

Attempts to cultivate the medicinal variety in this country have been unsuccessful, because the plant needs the growth conditions of central Asia (268, p. 410).

19. Senna. Senna, which is grown in Egypt and its neighboring districts and in southern India, is used in medicine as a laxative or cathartic. Imports during the post-war (World War II) years amounted to about 1,300,000 pounds annually and were mainly from India, China, and northern Africa.

No reports were found which discussed the possibility of growing senna in the United States.

20. Sorbitol. This is a sugar isomeric with mannitol and dulcitol. Sorbitol is largely used in the treatment of diabetics.

Sorbitol is found in ripe mountain ash berries, plums, pears, apples, etc. Atlas Powder is producing sorbitol from corn syrup; plans were made in 1950 to double the capacity of the production facilities (118).

21. Thymol. Thymol is usually obtained from the essential oil of Thymus vulgaris and of Monarda punctata. It is also made synthetically. Imports in the post-war years were of very small volume and were mainly from Germany.

Medicinally it is an anthelmintic and an antiseptic.

The oil derived from the native American mint (Pycnanthemum pilosum) is reported as yielding one-half its weight of menthol or thymol (99). Thymol has also been obtained from the seeds of Ptychotis ajowan (Carum copticum) by steam distillation. The yield is 3.5 per cent of an oil containing 36-39 per cent thymol. (134)

22. Vanillin. Vanillin, used as a flavoring agent, is usually obtained either synthetically or from vanilla, potato parings, or Siam benzoin. Imports were of very small volume in the years following World War II.

It is reported that vanillin of a very good grade can be procured from lignin from pine sources by a very simple process (167, p. 431; 259).

23. Vitamins. Several new sources of vitamins have been reported.

a. Among the products isolated from rice bran are biotin, folic acid, riboflavin, pantothenic acid, pyridoxine, thiamin, niacin and inositol. (196)

b. Distiller's solubles, yeast, soybean meal, peanut meal, cottonseed meal, and "spent" culture from penicillin fermentation are excellent nitrogen or protein sources for the broth in which the organism producing Vitamin B₁₂ is grown (71). Conversion of a Vitamin B₁₂-like substance to Vitamin B₁₂ is facilitated by using cyanide; the yield of Vitamin B₁₂ by this method is said to be three times that by the present method (73).

c. It is expected that synthetic Vitamin A production will soon supplant natural sources (249, p. 32).

d. Inositol comes mainly from the leaves of walnut and mistletoe. The output of inositol has been increased by the A. E. Staley

Company, but the demand is still greater than the supply. Corn steep liquor is the raw material being used (29).

A cheaper price for inositol would probably stimulate its uses in other fields besides that of medicine; e.g., in the synthesis of explosives, resins, surface coatings, and in the preparation of drying oils. A new method for the production of inositol is needed, since current prices are almost as low as is possible for the extraction method (29).

24. Other Botanicals of Interest. There are several items which have not been specifically mentioned as being short, but which should be mentioned because of their present or potential importance in the field.

a. Antibiotics.

(1) "Citrinin" has been derived from a mold growing on citrus fruits. It has proved effective against staphylococcus aureus, streptococcus, and pneumococcus. (8)

(2) Wild ginger (Asarum canadense) produces bactericidal agents as active as penicillin on some organisms. They are said to be active against staphylococcus, streptococcus and pneumococcus. (148)

(3) Nitrofurazone, an antibacterial isolated from corn-cobs, is also reported as being very powerful (212).

b. Blood Plasma Substitutes. Dried okra has been used as a substitute for blood plasma for animals. The product need not be refrigerated for storage. (96)

c. Curare Substitutes. Three synthetic drugs which have the same physiological effects as curare have been reported. They are named "Flaxedil," "Syncurine," and "Mytolon" (95).

d. Henbane. Between World War I and World War II about 100,000 pounds of two species were imported annually. Henbane grows wild in mountain valleys in the Northern Rocky Mountains. Some attempts were made to cultivate henbane during wars, but the plant was found to be very susceptible to the tobacco mosaic disease. (175, p. 63)

e. Mannitol. Facilities for the preparation of bulk samples of mannitol from seaweed are in operation in Scotland (115).

f. Opium Substitute. Drugs such as "Dromoran", "Demerol", "Heptalgin", and methadones may end the need for opium imports. These drugs are reported as being as effective as morphine and are generally non-addictive. (25, 35, 128, 229)

g. Rutin. Commercial production of rutin from buckwheat was begun in 1946. Previously rutin was obtained from tobacco, but this process is cheaper and results in higher yields of rutin (16). The potential domestic demand is estimated at 1,300,000 pounds annually. In 1945, 400 pounds were produced domestically; in 1946 it was estimated that more than 10,000 pounds would be produced (110). Greater production was expected in the future.

Recently it has been reported that mature asparagus is a source of rutin, but that using asparagus for rutin lowers the next year's edible crop (5).

h. Santonin. Santonin is usually obtained from Levant Wormseed, but the Japanese are producing santonin from a seaweed (Kaininsox) from Formosa (112).

i. Stramonium. Datura stramonium is a common weed in the eastern United States. It is easy to cultivate, but difficult to harvest and dry acceptably. Between World War I and World War II about 200,000 pounds

were usually imported annually (175, p. 63). Datura innoxia can be used as a source of scopolamine; it is not as easily cultivated as Datura stramonium, but the entire plant may be used. Levo-scopolamine (hyoscine) is the only alkaloid present (185, p. 450).

D. Waxes, Gums, and Resins

The United States has always been dependent on foreign sources of supply for a very large part of its requirements of natural waxes, gums, and resins. In some cases the product is available botanically in the United States, but it has not been practical to develop commercial production in this country.

Usually these products are imported from one or two places in the world where the cost of collecting them is low. This means that imports come from the more undeveloped regions of the world, where primitive natives collect the waxes and gums, often from wild growths, and then trade them to exporters. There are exceptions to this, as, for example, the huge rubber plantations of the Far East, which have far outstripped the production of rubber from wild stands in the Amazon valley.

During times of shortage in the past, various substitutes of generally inferior quality have been used when stockpiles were depleted. Much research on synthetics and substitutes has been undertaken during the last few years; varying degrees of success have been reported.

Shortages have often been the result of poor harvests at the source. Abnormal climatic conditions, internal warfare, or the discovery of new, more profitable income sources have hindered full production. During World War II, the breakdown of shipping facilities was responsible for many shortages. Furthermore, in some cases the primary

source was in the hands of the enemy; e.g., the islands of the Far East which produced 90 per cent of our rubber were captured by the Japanese.

In any case, it would be much better if sources of gums, waxes, and resins could be developed nearer the shores of the United States so that supplies of these necessary materials would not be subject to the risk inherent in thousands of miles of open-sea shipping.

Beeswax, candelilla wax, carnauba wax, and ouricuri wax have all been mentioned as being critically short. Imports of these waxes in recent years are listed in Table II.

TABLE II
IMPORTS OF IMPORTANT VEGETABLE WAXES

Product	Volume Imported (Pounds)		Major Sources of Imports
	1949	1950	
Beeswax	3,909,561	5,732,831	Latin America, Western Asia, Africa
Candelilla Wax	7,113,788	5,699,177	Mexico
Carnauba Wax	19,170,014	20,446,291	Brazil
Ouricuri Wax	2,370,688	2,757,290	Brazil

The properties of all these waxes and those mentioned as substitutes or replacements are recorded in Table III.

1. Commercial Waxes

a. Beeswax. Beeswax has been widely used for many centuries. Some of its manifold uses are in candles, for wax impressions, in modeling, for wood finishings, and as an insulating material. The National Farm Chemurgic Council has reported that beeswax is being used in

TABLE III
SOME PROPERTIES OF WAXES*

Wax	Melting Point (°C)	Hardness Values (Shore Durometer at 25°C)	Solubility** (Grams Per 100 ml.)			Color
			95 Per Cent Ethanol (25°C)	Chloroform	Others	
1. Beeswax, Yellow U. S. P.	63-64.2	43	0.340	sol.	Ether, CCl ₄ --sol.	Yellow to brownish yellow
2. Beeswax, white U. S. P.	64.7	66	0.340	sol.	Ether, CCl ₄ --sol.	Shiny white
3. Candelilla Wax	75.8-77.4	100	< 0.12	sl.sol.(cold) sol.(hot)	Ether--0.12	Yellow-brown
4. Carnauba Wax	83-86	100	0.141	1.69	Ether--0.421	Straw yellow to gray-black
5. Douglas Fir Bark Wax	63	83	--	--	--	Reddish brown
6. Hydrogenated Jojoba Wax	70	--	--	--	--	Lustrous pearly white
7. Curicuri Wax	79-84.5	100	0.350	sl.sol(cold)	CCl ₄ --sl.sol	Yellow
8. Sugar Cane Wax (Louisiana)	78	98	5.860	sol.	Ether--sl.sol.	Light brown

*See reference 258.

**sl.sol. = slightly soluble, sol. = soluble.

connection with the manufacture of at least four hundred articles--from ammunition, cosmetics, and medicines to protective coatings on airplanes (258, p. 61).

Carnauba wax and similar waxes have been used as substitutes for beeswax, but no methods for increasing the supply of beeswax available have been discovered in the literature covered in this survey.

b. Candelilla Wax. Candelilla wax is used quite extensively to harden other waxes. Its melting point is lower than that of carnauba wax; and it is, therefore, infrequently used as a melting point extender for wax compositions. It is commonly used as an ingredient in shoe polishes, floor pastes, phonograph records, sealing wax, candles, electrical insulators, waterproof boxes, and fabrics. (258, p. 119)

Candelilla wax is obtained from a weed, Pedilanthus pavonis, or from P. aphyllus, which grows in the semi-arid regions of northern Mexico, southern Texas, Arizona, and southern California.

No new sources of supply have been noted in the literature (258, p. 114).

c. Carnauba Wax. The primary use of carnauba wax is as the most important constituent of floor polishes. Its value lies in the fact that it produces the most durable luster and hardness of all waxes available. Candelilla and ouricuri wax have been used to some extent as substitutes, but they are inferior. Other uses of carnauba are in phonograph records, leather dressings, and in the manufacture of carbon paper, photograph films, chalks, matches, soap, unguents, dry batteries, etc. In many cases carnauba wax is used in conjunction with other waxes. (258, p. 107)

The habitat of the carnauba palm (Copernicia cerifera) is in the semi-arid Brazilian Northeast. It is estimated that the average yield of wax is about 2.8 ounces per cutting; there are usually two cuttings per year. There are probably about 50,000,000 trees in production.

(258, pp. 95-100)

d. Ouricuri Wax. Ouricuri wax is used as a substitute for carnauba wax in floor waxes, shoe creams, and other polishes, although it is somewhat inferior. It is also valuable in the inks used on typewriter carbon paper as it provides a means of securing sharply defined type impressions. It is reported that ouricuri wax has been used in the finishing of bombing and fighting planes, giving highly polished surfaces that are resistant to air friction and to wetting and condensation.

Ouricuri is derived from the under surface of the leaves of a tropical American palm (Scheelea martiana). The wax is very hard and in color is not unlike the darker grades of carnauba. (258, p. 112)

2. Possible Replacements for Commercial Waxes. Several waxes have been mentioned as replacements or substitutes for these waxes. Some have been used before and some have only been recently considered as substitutes. Those which appear to be of particular importance are discussed below.

a. Caua ã ú Wax. This is a new wax recently studied by Brazilian chemists. It comes from the leaves of the plant caua ã ú (Calathea lutea) of the Marantaceae family and is found in the Amazon valley. Further work on applications and refining is now being done.

(100)

b. Douglas Fir Bark Wax. Few barks can be used to produce wax in commercial quantities; the Douglas fir bark is probably the most

promising. It contains five to ten per cent of a hard, non-tacky wax interspersed in the corky layers of the bark and accompanied by resinous matter (145; 258, p. 148). This wax can be extracted with a hydrocarbon solvent, and it is reported that nearly one hundred per cent solvent recovery is possible (145).

There are large quantities of this bark in the waste at American Douglas fir lumber mills in the Northwest that can be utilized for this purpose (258, p. 146). A plant for extracting wax from Douglas fir bark has been built in Oregon by the Oregon Wood Chemical Company (94). Wax potentially valued at \$75 million can be produced from 125,000,000 cubic feet of sawlog bark annually (145).

c. Hydrogenated Jojoba Oil. Jojoba (Simmondsia chinensis) yields an oil which can be hydrogenated by a process similar to that used for hydrogenating cottonseed oil. The hydrogenated Simmondsia oil is a hard, crystalline, white wax having a melting point only slightly lower than that of carnauba. Simmondsia wax is harder than any wax on the market except carnauba, and it is possible that it can be made as hard as the carnauba wax. (179, 216)

Hydrogenated Simmondsia wax can be used in the preparation of polishing waxes, manufacture of carbon paper, waxing of fruit, impregnation of paper containers, and in many other processes (216). Candles made from Simmondsia wax do not melt before being used, even in hot climates (180).

Other uses of Simmondsia and possibilities of its development commercially are discussed elsewhere in this report.

d. Wax From Henequen Pulp. The Armour Research Foundation reports that a replacement for Brazilian carnauba wax is now available

from the Yucatan peninsula. This new wax is extracted from the waste pulp from which henequen or sisal fiber for ropes has been taken. The wax has properties similar to those of carnauba. It is hard, has a melting point of about 185° F., and bleaches readily to an almost colorless material for industrial finishes and coatings.

Some 10,000,000 pounds of wax can be made annually from available sisal waste pulp (19).

e. Sugar Cane Wax. Cane wax has been used to a limited extent in the polish and electrical industries, for phonograph manufacture, and as a replacement for carnauba, beeswax, and montan wax in other industries. "Samples of American wax of 174° F. melting point sent to the trade... indicate there will be a good demand for the product whenever it is produced in quantity." (258, p. 138)

Production of sugar cane wax was carried out in Natal, Union of South Africa, during World War I, but production lapsed after the war (160). Wax has also been recovered on a commercial scale in Java. Wax has been produced in the province of Tucuman in Argentina, in East India, on Cuban estates, and elsewhere; however, it has not been done on a commercially profitable basis (258, p. 131).

During and after World War II interest in sugar cane wax increased, and a plant for its production was opened in Louisiana by the Cuban-American Sugar Company (160).

The estimated cost of extraction from the press cake (in 1948) was 8.75 cents per pound of crude wax, exclusive of the price of the press cake itself. It was estimated that the total cost would be less than the current price of vegetable waxes in the market. (160)

f. Wax From Petroleum Residues. United States Patent 2,546,328 is reported as covering a substitute for carnauba wax which is superior to others already developed. The crude wax source is waxy petroleum residues and deposits on crude oil tank bottoms. (123)

g. Non-Melting Wax From Standard Waxes. An additive to standard waxes which gives a non-melting wax is reported by the Flexrock Company, Philadelphia. The company claims that it can convert any standard wax into a non-melting wax, mainly adaptable to industrial uses. (88)

3. Gums and Resins

Most of the vegetable gums and resins, like waxes, are imported from distant sources. Those mentioned as being in short supply are agar, alginates, gum arabic, gum benzoin, Canada balsam, Copaiba balsam, Congo copal, damar, gumboge, karaya gum, locust bean gum, Manila copal, gum mastic, Peru balsam, pontianak, rosin, sandarac, shellac, Tolu balsam, and tragacanth gum.

Rubber was also found to be in short supply and is discussed herein, although it is not strictly classified as a gum or resin.

a. Agar. Agar is a complex polysaccharide that forms a colloidal solution in hot or boiling water and has a remarkable gel-forming capacity. It is obtained only from certain species of a group of seaweeds known as red algae (Class Rhodophyceae). The main uses of agar have been as a bacteriological culture medium, as a stabilizer in foods, and in medicine.

Prior to World War II, Japan held a monopoly on commercial agar by virtue of the development of the industry in the Orient and the abundant supply of agar bearing seaweeds along the Japanese coasts.

With the outbreak of World War II, agar became critically short and its use was restricted to bacteriological culture media. During the preceding twenty years, over ninety per cent of all agar used in the United States came from Japan (199, p. 317). As a result of the war the agar industry in California, which had begun in 1920, was revived and expanded. At the same time, new sources of agar were sought; the establishment of the agar industry on the Atlantic coast of the United States was a result. Production in the United States reached 165,954 pounds in one year during the war (253, p. 10).

Since the close of the war, importation from Japan has been resumed, and the future of the North American agar industry is uncertain. It is hoped that the imposition of protective tariffs will help the American industry compete with the cheaper Japanese product.

The greatest part of the American production is along the southern coast of California, but there is also some production on the Atlantic coast. The United States could produce its own supplies of agar if the need should arise, as was proved in World War II (215, p. 27; 199).

b. Algins and Alginates. Algin is a valuable colloidal substance occurring in many brown algae, especially kelps. It has been extensively employed in the food, cosmetic, and other industries.

On the European and American coast of the Atlantic Ocean two species of marine kelps, Laminaria digitata and Laminaria saccharina, are harvested as raw materials. On the Pacific coast of the United States two other species, Macrocystis pyrifera and Nereocystis luetkeana are gathered for the same purpose (253, pp. 70, 72). It has been estimated that the production of algin and alginates in this country is over 2,000,000 pounds per year, with a monetary value of \$1,500,000 (209, p. 318).

c. Gum Arabic. The "gum arabic" of commerce is the dried gummy exudation from the trunks and branches of many species of Acacia. The term has been applied also in a very broad general sense to almost any gum, regardless of its botanical source, which will disperse in water to form a mucilage. True gum arabic, however, is yielded only by certain species of Acacia (215, p. 5).

Gum arabic has been imported, mainly from northern Africa, at the rate of about 17,000,000 pounds annually since World War II. No information has been obtained which would indicate that there is a possibility of obtaining this gum from domestic production.

d. Gum Benzoin. Benzoin or "gum benjamin" is the dried resinous balsam obtained from several species of Styrax, forest trees in the Asiatic tropics.

Benzoin is used as a carminative, expectorant, and diuretic. It can be applied externally to wounds and is one of the main ingredients of Friar's balsam. Gum benzoin is also used in the cosmetic industry as a fixative.

Synthetic benzoin is now produced on a commercial scale (197, 167).

e. Balsams. Of the various balsams used commercially, the most important are Canada balsam, Copaiba balsam, Peru balsam, and Tolu balsam. The main uses of these are in the medicinal and pharmaceutical field.

(1) Canada balsam is obtained mostly from the balsam fir (Abies balsamea), one of the most widely distributed conifers in North America. The tree's habitat extends from Labrador to Virginia.

A feature of Canada balsam is that it has little tendency to crystallize or granulate upon drying. This makes it valuable for the preparation of microscope slides and in other optical work.

(197, p. 155)

(2) Copaiba balsam is the oleo-resin obtained from the trunk of Copaifera langsdorffii and other South American species of Copaifera. There are several commercial varieties of Copaiba balsam which differ somewhat in appearance and composition. These are usually known by the names of the towns from which they are exported. (197, p. 158)

(3) Peru balsam comes from the tropical American tree Myroxylon pereirae, the habitat of which extends from southern Mexico southwards through Central America, mainly on the Pacific side (197, p. 163).

(4) Tolu balsam comes from the tree Myroxylon balsamum, which is so closely related to the tree yielding Peru balsam as to be considered the same species by some writers (197, p. 163). Most of the Tolu balsam that enters commerce is obtained from Columbia and Venezuela. It is used mainly in the perfumery industry and as a flavoring for medicinal mixtures. The balsam has also been used as an adulterant of the more valuable Peru balsam.

f. Copals. "The term copal is used in English and American markets and in the resin trade generally for a large group of resins characterized by their hardness and relatively high melting point." (197, p. 92) Some of these are among the best of the natural resins for use in varnish and paint manufacture. The harder copals, on account of their thermoplastic character, have been used as a binder, often in combination with shellac.

The copals are derived from several different plants but mainly from forest trees of the family Leguminosae that occur in different parts of the world.

(1) Congo copal has been the most important copal in the world's market during the last two or three decades. About 4,000,000 pounds of copal have been imported annually from the Belgian Congo in the years following World War II.

Congo copal is used in the varnish industry because of the weather resistant surface it imparts. It was the first resin to be used in the preparation of so-called "wrinkle finishes" (214, p. 100).

(2) Manila copal, or East Indian copal, is derived from a single botanical source, Agathis alba, a tall forest tree which is widely distributed in the East Indian region. It occurs throughout Malaysia from Sumatra to the Philippines, Moluccas, and New Guinea. (197, p. 100) Manila copals are frequently used in preparing shellac substitutes.

(3) Pontianak is a semi-fossil copal which is a member of the Manila class. It originates in Borneo as a product of the tree Agathis borneensis. It is used chiefly as an oil-varnish resin (214, p. 74).

About 6,500,000 pounds of copals annually (exclusive of Congo copal) have been imported in the years 1949-50.

g. Damar. The "damars" of commerce are resins from trees of the family Dipterocarpaceae, including several genera. Those damars imported, insofar as the United States is concerned, come almost exclusively from the islands of Sumatra and Borneo in the Netherlands East Indies (214, p. 33). The specific name of each damar comes from

the name of the port from which it is exported, e.g., Padang damar (197, p. 116).

Damar is used as an ingredient of flame-proof enamels, in varnishes for toys and cheap jewelry, and in sprays for giving a high gloss to citrus fruits, hard candies, and transparent window envelopes (214, p. 32).

h. Gamboge. Gamboge is collected mainly on the islands on the east coast of the Gulf of Siam, the Siamese province of Chantaburi, and also Cambodia and lower Cochin-China.

Its main use is as a pigment in water colors and in making gold-colored spirit varnish for metals (197, p. 161).

i. Karaya. Karaya gum, or Indian tragacanth, is obtained from Sterculia urens, a tree which is very widely distributed in India (197, p. 41). It has become an important raw material in the textile, cosmetic, food, and other industries because of its resemblance to gum tragacanth. (215, p. 17)

Imports are mainly from India and have amounted to about 8,000,000 pounds annually in the years following World War II.

j. Locust Bean Gum. This gum is obtained from the seeds of the carob, or locust bean tree (Ceratonia siliqua). The tree is a native of Syria and has been cultivated from antiquity in many Mediterranean countries (215, p. 21).

The pods of the tree have been used as food for both humans and animals. Locust bean gum has been used in the United States as a substitute for gum tragacanth in the rubber-making industry, in paper-making, in tanning, and in certain food preparations.

Imports of locust bean gum in the years 1949-1950 amounted to about 9,000,000 pounds annually and were almost entirely from the Mediterranean countries.

The gum of guar, Cyamopsis tetragonoloba, has been mentioned as a substitute for locust bean gum. Guar is an annual, summer-growing, drought-resistant, soil-improving legume that has been imported from India (262). It shows promise of providing a consistent, easily regulated supply of gum-containing seed. Since it is an annual, and since it can be harvested with standard agricultural equipment, it can be worked into the crop rotation plans of farmers in qualified areas of this country.

Recently General Mills Research Laboratories have been studying this plant as a potential commercial source of vegetable gum and have been developing milling methods to separate the gum from other portions of the seed. This laboratory, in cooperation with the United States Department of Agriculture, has also been sponsoring cultivation of guar by farmers and ranchers on irrigated lands in southern Arizona and southeastern California. (181)

Guar seeds yield forty per cent mucilage which can be milled from the seed (2). Investigations have shown that guar flour is of value for improving the strength of certain grades of paper. Good grades of guar flour have five to eight times the thickening power of starch (262).

"It has been said that guar possesses properties which might be useful in warp-sizing, printing pastes, and in certain finishing operations." (215, p. 22) It is also useful as a thickening agent for various food preparations (262).

Investigations indicate that guar will provide an important substitute for locust bean gum and may prove to have important uses in its own right.

Another plant which might yield a substitute for locust bean gum is tara (Caesalpinia spinosa), which is exported from Peru. The pods are used in tanning, but the seeds yield a mucilage which might prove useful.

(2)

k. Mastic. Commercial gum mastic is imported mainly from Greece and is the resinous exudation of Pistacia lentiscus. The collection of mastic is largely limited to the islands of Chios in the Aegean sea, although small amounts are collected elsewhere in the Mediterranean area. Recent imports have amounted to 18,560 pounds in 1949, and 4,548 pounds in 1950. From January through July of 1951, 7,736 pounds were imported.

Mastic is used mainly in the varnish industry for the preparation of high grade varnishes of very pale color for special purposes (197, p. 138; 214, pp. 79-80).

l. Rosin. Pine trees of many species yield, when tapped, a natural oleo-resin, which is distilled into two important products--turpentine and rosin.

The uses of rosin are largely governed by its grade or quality. The superior grades are used in the preparation of pale varnishes and to a small extent in some pharmaceutical products, the medium grades are used in soap manufacture, and the lower grades are used as sizing materials.

The United States has been the world's largest producer of "naval stores" (rosin and turpentine) for more than a century, producing about 70 per cent of the world's supplies of rosin and turpentine. The naval stores industry in the United States is located mainly in the southeastern states.

The trees exploited for naval stores in the United States are, for the most part, the longleaf pine (Pinus palustris) and the slash pine (Pinus caribaea), the former yielding the bulk of the resin. There are about 52 million acres of potential longleaf and slash pine land in the southeastern part of the United States (197, pp. 105-6).

The rosin and turpentine industry in the United States could probably be developed to a much greater extent than it is at present, especially since new synthetic products have been developed from naval stores derivatives. (69, 75, 78, 79, 80, 84)

m. Rubber. Before World War II the major portion of the rubber supplies for the United States came from the great rubber plantations of the Far East. When the war began, this source of supply was cut off, and other sources were found. Synthetic rubbers were developed, and collection of wild rubber in the Amazon basin was found to be economically feasible once more, after having been too expensive to compete with the plantation rubber during the years of peace. At present, synthetic rubber is used for a large amount of the United States' rubber needs (45, p. 10), and attempts are being made to develop domestic sources of rubber and to increase rubber production in the American tropics.

Hevea brasiliensis is the best source of high-grade natural rubber. This is the tree grown on the plantations of the Far East and one of the two from which rubber latex is gathered in the Amazon basin. Various attempts have been made to grow rubber on plantations in the Western Hemisphere in Liberia, Brazil, Panama, Costa Rica, the Guineas, and Trinidad. These attempts have all failed, principally because of the infection of the trees by South American leaf blight. Recently, as a result of wartime research, a satisfactory degree of control of the

blight has been attained. Work is also being done to develop a high-yielding, blight-resistant tree and to foster the planting of Hevea in family-size plots throughout several Latin American countries (261, p. 209). The United States Rubber Company has been experimenting with growing Hevea in greenhouses in the United States to test the effect of various fertilizers on yield and blight resistance (45, p. 11).

The second most important of the rubber-bearing trees of the Western Hemisphere are certain species of the genus Castilla, tropical member of the mulberry family. The yield annually from Castilla is lower than that from Hevea (one to two pounds as compared with 10 to 25 pounds), and the rubber is usually considered to be inferior to that from Hevea. Castilla is subordinate to Hevea because of the low yields and because of difficulties in developing satisfactory methods of tapping.

The most important rubber-bearing plant native to the United States is guayule (Parthenium argentatum). The plant is native to the north-central plateau regions of Mexico and to the Big Bend area of Texas.

Guayule rubber has been on the market for a considerable length of time. In 1909 Mexico exported 9,542 long tons of guayule rubber to the United States. For a time guayule was a strong competitor of Hevea, but the advent of cheap plantation rubber of a high grade soon placed guayule in a very minor position (250, p. 256). Attempts to grow guayule commercially in this country have been made ever since about 1914. At the outbreak of World War II, the United States government became interested in guayule and instituted research development projects on guayule rubber. These projects were cancelled at the end of the war, but research on many phases of the production of guayule has again been instituted by the United States Department of Agriculture (250, p. 261).

Rubber latex is found in all parts of the guayule plant, but it is found in considerable quantity only in the stem and root. New strains have been developed which yield from 25 to 40 per cent more rubber than the best strains of World War II (45, p. 12).

The rubber which is produced from guayule is a highly resinous product of a grade and quality not altogether satisfactory for general use. A very simple process for the deresination of guayule has been developed by the United States Bureau of Standards (150).

Guayule is considered as a crop for arid lands in the Southwest. Cultivation methods are still being developed (45, p. 12).

Kok-saghyz, the so-called Russian dandelion (Taraxacum kok-saghyz), has been imported from Russia for the purpose of determining its possible use as a rubber source.

During World War II experimental plantings were made in 42 states. It was found that the plant is adapted to growth in the northern states and in Canada during the summer. The most successful plantings were those made in Vermont, Michigan, Wisconsin, Minnesota, and Oregon. Successful winter plantings have been made in Florida and Texas.

Cultivation of kok-saghyz is relatively simple, though it will be necessary to develop a much more vigorous and competitive plant before economical planting will be possible. The quality of rubber obtained from the experimental plantings proved to be equal to or, in a few cases, better than the Hevea rubber used as the standard.

The rubber latex is found in the leaves and roots. The leaf rubber is highly resinous and is a poor product. The root rubber has a low percentage of resins and is a very high-grade product (261, p. 215).

Other plants have been mentioned as sources of rubber, but most of these show very little promise (261, p. 216-17). Several new synthetic rubbers have been mentioned in the literature, together with some developments for improving rubbers already in production (58, 136).

n. Sandarac. Sandarac is a resin obtained from Tetraclinis articulata trees. The commercial product comes from northern Africa.

This resin has been used to some extent medicinally, but it has been used largely in fine grades of lacquer and spirit varnishes (197, p. 136; 214, p. 81).

o. Shellac. Shellac is the refined form of the "lac" secretion of an insect [Laccifer (Tachardia) lacca] which is found in India.

The average annual world production of lac in the years preceding World War II is estimated as 30,000 tons; India provided about 90 per cent of this (197, p. 131). The lac trade in the past has been characterized by instabilities in prices, supplies, and quality--potent factors in restricting the industrial uses of lac and in favoring the use of synthetic resin substitutes where these are suitable. Many of the resins already mentioned in this report have been used as substitutes for shellac.

p. Tragacanth. Gum tragacanth is probably second in importance among the commercial water-soluble gums, being surpassed only by gum arabic and rivalled only by gum karaya. The gum is obtained from several species of Astragalus that occur in the mountainous regions of Asia Minor through Syria and Kurdistan to Iraq and Iran. (197, p. 39)

The main uses of gum tragacanth are in calico printing and in pharmacy as a thickener. It is also used in other industries in places where a good thickener or sizing agent is required. (197, p. 15)

Gums regarded as substitutes for tragacanth include karaya gum, locust bean gum, and Kutira gum (197, p. 5).

The development of new synthetic resins will probably decrease shortages of many of these gums and resins to a large extent.

E. Miscellaneous Materials.

1. Insecticides. The insecticides reported as being in short supply are benzene hexachloride, DDT, nicotine sulfate, pyrethrum, rotenone, sabadilla, and toxaphene. Of these shortages, the lack of pyrethrum was probably the most serious because of its many uses.

The pyrethrum shortage was due in large part to decreased imports and wider applications. Pyrethrum flowers are imported mainly from Africa to the extent of about 10,000,000 pounds annually. Some attempts have been made to grow pyrethrum in California, but no large scale work has been done (203, p. 11).

A pyrethrum synthetic, allethrin, has been developed, but its synthesis is rather expensive (225). Research is still progressing to determine its effects on some flying insects, but preliminary reports are optimistic (255, p. 248). Of all the synthetic insecticides developed since the war, this is the only one non-toxic to man and animals. It is hoped that allethrin and similar products may relieve the United States' dependence on imports of pyrethrum should supplies be cut off. (225)

The raw materials for rotenone can now be obtained from South America as well as from the Far East (193; 242, p. 17).

Several new developments of other insecticides have been reported. A material of promising potential is scabrin, an amide found in the roots of the native perennial weed "ox-eye" (Heliopsis scabra) (255, p. 249).

Scabrin has been reported several times as effective as pyrethrum in killing houseflies. A southwestern plant, Physalis mollis, commonly known as the smooth ground cherry, yields a chemical (probably an alkaloid) which is also an effective fly poison (91).

Certain other plants have been mentioned as sources of insecticides; many of these are under investigation by the United States Department of Agriculture and other interested organizations, but their commercial value has not yet been determined. Some of these plants and their possible applications are listed in Table IV (234).

TABLE IV
INSECTICIDAL PLANTS OF POSSIBLE FUTURE IMPORTANCE

Plant	Habitat	Insects Affected
<u>Haplophyton cnicoidum</u>	Mexico	Cockroaches, flies, fleas
<u>Heliopsis longipes</u>	Mexico	Houseflies, moth larvae
<u>Ryania speciosa</u>	Mexico	Cabbage worms, squash bugs, moths
<u>Tripterygium wilfordii</u>	China	Moths, cabbage worms
<u>Anabasis aphylla</u>	Russian Steppes	Aphids, soft-bodied insects
<u>Phellodendron amurense</u>	Asia	Mosquito larvae, houseflies, moth larvae
<u>Zanthoxylum clava-herculis</u>	North America	Used with pyrethrum (synergist)
<u>Aeschrion excelsa</u>	Jamaica	Aphids
<u>Duboisia hopwoodii</u>	Australia	Aphids, mites

2. Tannins. About 120,000 tons of 100 per cent tannin are used annually in this country for tanning purposes (203, p. 3). In addition, tannins are used in the treatment of boiler water, in mining, in oil well drilling, and in production of dyes.

Until about 1900, native hemlock (Tsuga canadensis) and chestnut oak (Quercus montana) barks were the principal domestic sources of tanning materials, and large amounts of these were exported as well as used in the United States (239). These were succeeded by chestnut wood (Castanea dentata) which is now the main commercial source of native vegetable tannin in this country. Chestnuts, however, have been nearly exterminated by blight during recent years (224) and supplies of the wood are expected to last only ten or fifteen years longer (203, p. 4).

At present the United States provides only about 30 per cent of its requirements of vegetable tanning materials, principally from chestnut oak bark, chestnut wood, and hemlock bark (165). The bulk of the imports consists of quebracho from Argentina, Brazil, and Uruguay and wattle from Africa; smaller amounts of mangrove, myrobalans, and divi-divi are also imported (254).

During the course of the literature survey, the following tanning materials were mentioned as being in short supply: chestnut bark and extract, cutch, divi-divi, mangrove bark, quebracho, sumac, valonia, and wattle bark and extract.

Quebracho (25 per cent tannin) is the major tanning material imported at the present time; in 1945 imports of quebracho amounted to 290,973 tons. For the same period, 72,677 tons of wattle extract (also 25 per cent tannin) were imported.

It is estimated that supplies of quebracho will last for at least another 15 to 20 years. The quebracho suppliers, however, are subject to the manipulations of an international cartel; in addition, the sources of supply are receding farther and farther from means of transportation (203, p. 5). This situation seems to indicate that the future of quebracho supplies is rather uncertain.

Wattle bark and extract are imported from South Africa, where the plant is cultivated. Only a small amount of this material is exported to the United States, mainly because of trade preferences within the British Empire. Recently, wattle imports to the United States have been increased because of the dwindling supplies of chestnut wood in this country (203, p. 13) and the relaxation of trade restrictions.

The various species of Acacia which yield wattle are probably the best sources of tanning material used at this time because of the large amounts of high quality tannin which are obtained. Some wattle culture has been attempted in Brazil and the results this far have been very promising. Experiments at the University of California indicate that wattle can be grown in the United States, although there was no commercial production reported in the literature.

It has been estimated that if domestically produced wattle bark could replace all of our imports of quebracho and 75 per cent of our consumption of domestic chestnut tannin, our total yearly requirements of Acacia tannin would be 455,900 tons of extract containing 25 per cent tannin. To do this it would be necessary to have 375,000 acres of Acacia under cultivation. (203, p. 14)

Other sources of tannins have been mentioned in the literature.

a. Canaigre (Rumex hymenosepalus) has been investigated under the auspices of the United States Department of Agriculture. This is a

dock-like plant, the roots of which yield up to 35 per cent tannin when dried; it grows in the arid southwestern United States (239). Enough material has been harvested to allow pilot plant operations, and its cultivation and harvesting over a period of one or two years seems feasible (207, p. 373; 265, p. 132).

Canaigre is an excellent tanning agent and can produce high yields of good leather (254). Heretofore, its utilization has been hampered by the difficulty in obtaining an extract of high tannin content because of carbohydrate materials present, including soluble sugars and starch. Recent research indicates that this difficulty may soon be overcome (203, p. 19).

b. The cascalote tree, abundant in Mexico, may also provide a new tannin source for this country. Work done by the Armour Research Foundation has been aimed at overcoming the perishability of the extract, the main problem in the past. The extract has been concentrated and dried to form a solid which is an extremely uniform product and is easier to transport and measure than the material formerly obtained from this source. The process has proven successful in small pilot plant tests, but larger plantings of cascalote must be made if the process is to be continued commercially. (86)

c. Native sumacs have also been investigated as a source of tannin. Several species have shown promise. The best, Rhus copallina, or dwarf sumac, yields a tanning material which compares favorably with that of the Sicilian sumac (254), 4,500,000 pounds of which were imported annually during the prewar years (239). Two other species are reported to yield tannin of slightly lower quality. It is hoped that breeding of domestic sumacs may improve the quality of tannin obtained from these sources (143).

d. Western hemlock, spruce, and redwood have shown some promise as tannin sources, but the necessary long-distance transportation, as well as other difficulties, prevents serious commercial consideration (265, p. 133).

Buttonwood, scrub willow, and scrub oak have also been mentioned in some reports, but no widespread attempts at application have been made (203, p. 17). Tannin has been extracted from the liners of pecan shells on a commercial basis; and in 1948 the Texas Tannin Extract Company was shipping about 160,000 pounds of 33 per cent tannin per month (140).

e. The shortages of fats and oils for tanning has caused an increase in research on new synthetics. Several private laboratories as well as government agencies have been investigating synthetic tannins (55). Synthetics already have a place in the tanning industry; such products as "Orotan", "Chemtan", "Intan" (265, p. 133), "Exan", "Calgon", and "Leukanols" (203, p. 20) are well known in the trade. In spite of the shortages of vegetable tannins, the development of synthetic tannins has caused great optimism among leather chemists (55).

3. Food Products and Flavorings. Of the items included in this section, only black pepper was found to be significantly short in supply. Black pepper is a major import commodity of the United States. In recent years the average annual imports were 28,000,000 pounds, mainly from India and Indonesia.

Work has been done on the volatile oils of Piper nigrum and the results obtained indicate that some chemical substances might serve as substitutes for pepper (200).

Those items that were mentioned as being insufficient in supply only at scattered times in the first four years of the survey include:

arrowroot starch,	ginger root,
calendula flowers,	poppyseed,
caraway seed,	savory,
citrus fruits,	sweet potato starch,
cocoa beans,	tapioca flour,
corn starch,	thyme, and
corn syrup,	taro powder.

Those items that were in short supply during the latest two years covered by the survey are:

celery seed,	mustard seed,
chicory,	potato starch,
cinnamon,	sago flour,
cloves,	sarsaparilla,
cocoa butter,	sugar,
coffee,	tea,
marjoram,	turmeric,
Mexican allspice,	vanilla and vanilla beans, and
pimiento seeds.	

4. Chemicals. Various chemicals were reported as being in short supply at times throughout the years covered by the survey. Most of these were not lacking consistently, as the shortages were only mentioned a few times. These items included:

abietic acid,	geraniol ionones,
anethol,	geranyl acetate,
anisaldehyde,	isoeugenol,
azelaic acid,	lemon terpenes,
camphene,	linalool,
citric acid,	oleic acid,
citronellal,	quinolinic acid,
citronellyl acetate,	rhodinol,
coumarin,	sebacic acid,
cyclamine aldehyde,	stearic acid,
ethyl vanillin,	tartaric acid,
furfural,	terpineol, and
geraniol,	undecylenic acid.

The alcohols containing from one to five carbon atoms, and some chemicals derived from them, were found to be in great demand throughout the period included in the survey.

At the present time, methyl alcohol is produced almost exclusively by the reduction of carbon monoxide. Although methanol can be obtained by the destructive distillation of wood, this process cannot compete economically with the synthetic production of the material.

More than half of this nation's industrial ethanol is now being made synthetically, and the utilization of molasses and grains for this purpose is decreasing. The reasons that have been given are that (1) molasses supplies have been too scarce, (2) grains have been too costly, and (3) potatoes, which have been used, are too troublesome (247).

Propyl alcohols are produced commercially by synthetic means.

Butyl alcohols are also produced synthetically, but n-butanol can be and has been produced by a fermentation process of grains.

Amyl alcohols are synthesized from pentanes. Commercial quantities are also obtained from fusel oils, which are formed as by-products in the production of ethanol by fermentation.

Suggestions concerning increased alcohol output include a fungal amylase process for producing ethanol from grain without malt. This process has limitations, however, as the flavor of the products differs from that obtained by the malt process and is not suitable for beverage purposes. The cost of alcohol from grain using the fungal amylase process is lower than that using the malt process but it cannot compete with the cost of alcohol produced from molasses (41, 65, 223). Another process which has been exploited to some extent produces ethanol from wood wastes (113, 151, 192, 195). Also of interest is the recovery of molasses which can be used for cattle feed, sugar, and a high-protein livestock feed from wood wastes (192, 211). High-grade molasses derived from citrus fruits has been proven possible. This, of course, is another potential source of alcohol (23, 169).

Work has also been undertaken on a process for preparing butyl alcohol by fermenting the xylose present in corncobs. This process, when perfected, would undoubtedly be applicable to sugar liquors from corn stalks, straws, cottonseed hulls, and like materials (144).

Glycerine, which was not readily available throughout the years included in the survey, is normally a major by-product of soap manufacture. The increased use of detergents in recent years has been partly responsible for this glycerine shortage. Glycerine is also made synthetically from propene and has been made by a fermentation process from molasses.

Ethyl glucoside has possibilities as a replacement for some glycerine uses; however, production has not reached the pilot plant stage as yet. A synthetic product, however, glycol bori-borate has been used as a glycerine substitute (246).

Cellulose and several of its derivatives were mentioned as being in short supply during the course of the survey. Those derivatives mentioned were cellulose acetate, cellulose butyrate, cellophane, collodion, ethyl cellulose, and nitrocellulose.

It has been reported that a portion of cellulosic material now discarded can be used for acetate films after treatment by a newly developed process. Even material rich in pentosan (such as corncobs) can be used in this way (237).

An English firm has developed a bacterial process for obtaining dextrin and cellulose from cane sugar and is now operating a plant using this method (139). In Europe, also, successful experiments have been conducted in obtaining good quality cellulose from eucalyptus and casuarina wood (73).

Turpentine has also been mentioned as being in insufficient supply, but the naval stores industry has already been discussed in connection with the shortage of rosin.

VI. CONCLUSIONS AND RECOMMENDATIONS

After reviewing the results, it is believed that the procedure used in the literature investigation has been satisfactory for obtaining the information desired. The survey has indicated that there are widespread shortages of many plant raw materials necessary to industry.

Among the most critically needed fats and oils were drying oils, particularly those containing conjugated unsaturation. Those essential oils used in large volumes, such as citronella and lemon-grass oil, were also required in quantities exceeding the supply. The need for a domestic source of lauric acid oils was also expressed.

The most significant shortages of fibers and wood products included both cordage fibers and wood pulps for paper manufacturing. Bristles of the quality necessary for the production of paint brushes were also extremely difficult to obtain.

Shortages of many drugs and pharmaceutical products were noted. Those of the greatest consequence were ergot, atropine, cortisone, and menthol.

Carnauba wax and substitutes for it and other hard waxes were needed. Supplies of many water soluble gums and vegetable resins were inadequate, with very little chance of relief in the near future. Rubber latex was potentially in a very critical position as far as sources of supply are concerned.

Other materials which were reported as being in extremely short supply were alcohols, cellulose derivatives, glycerine, black pepper, pyrethrum, and tannins.

Some shortages exist because the major sources of supply are in regions which are now controlled by governments inimical to the United States and no longer trading with us. In some places food crops are being promoted, or producers are planting more profitable crops. Blights, or widespread destruction of some crops and production facilities, have caused decreased supplies of some materials.

This survey has also revealed numerous plants which may have potential value as sources of substitutes or as replacements for products which are critically short at this time.

An extension of the literature survey would probably be of value. Certain of the periodicals which were examined in this survey yielded very little information which was not duplicated in others. These could be eliminated without decreasing the thoroughness of the investigation.

~~Respectfully~~ submitted:

H. H. Sineath,
Assistant Project Director

Phillip M. Daugherty,
Research Assistant

Approved:

Herschel H. Cudd,
Project Director

T. A. Wastler, Jr.,
Research Assistant

Gerald A. Rossetlot, Director
State Engineering Experiment Station

VII. APPENDIX

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Georgia Institute of Technology
STATE ENGINEERING EXPERIMENT STATION
Atlanta, Georgia

PHASE REPORT NO. 1

PROJECT NO. 177-120

SURVEY OF THE NEEDS OF INDUSTRY
FOR
RAW MATERIALS FROM NEW PLANTS
TO BE
GROWN IN THE UNITED STATES

By

H. H. SINEATH

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CONTRACT NO. A-1S-33022

DIVISION OF PLANT EXPLORATION AND INTRODUCTION
BUREAU OF PLANT INDUSTRY
UNITED STATES DEPARTMENT OF AGRICULTURE

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JULY 16, 1951

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I. SUMMARY

This report presents the results of the initial phase of a survey to determine the needs of industry in the United States for raw materials from plant sources. The project was instigated by C. O. Erlanson, Chief of the Division of Plant Exploration and Introduction of the Bureau of Plant Industry of the United States Department of Agriculture.

Contacts were made by correspondence and interviews with national associations, universities, research institutes, and governmental laboratories. From these sources suggestions regarding needs were received and companies which should be interested in this work were recommended for contact.

The preliminary results indicate that the raw materials needed can be classed in the following categories:

1. Oils
2. Fibers
3. Drugs and pharmaceuticals
4. Waxes and gums
5. Miscellaneous materials.

The most critical needs were found to be hard fibers, oils, and certain drugs such as ergot and atropine.

Since the method used in the survey has been considered satisfactory, it is recommended that it be used in future work. Other recommendations include the following:

1. Statistical surveys of raw material consumption and of imports by country and commodity should be made. These would be valuable as economic guides and might provide leads to raw material needs.

2. Contact should be made with the industries suggested by the organizations initially contacted as well as approximately 800 additional organizations which have been selected according to the raw materials which they use.

The pursuance of these recommendations should provide maximum coverage, which, when complete, should present a representative picture of the needs of industry for raw materials from plant sources.

II. INTRODUCTION

In 1947 the Bureau of Plant Industry activated, through the Research and Marketing Act of 1946, a cooperative national program for the introduction and testing of new plants of potential value to American agriculture. The program placed special emphasis on those plants which might be utilized in chemical and manufacturing industries. At the instigation of its Director, C. O. Erlanson, the Division of Plant Exploration and Introduction requested that the Georgia Institute of Technology make a survey of the needs of industry for raw materials from plant sources. The primary objectives of the survey are:

1. To review the literature to determine the recognized needs which have been published.
2. To contact industry directly to get firsthand information on the industrial raw material needs.
3. After needs have been established, to determine
 - a. How much is needed;
 - b. The price that could be expected per unit for the material;
 - c. The effect of price on the volume needed for use.

The results of the survey will present a more comprehensive picture of the raw material needs of industry and will serve as a guide in the search for plants of potential value to American agriculture.

A program was designed to accomplish stated objectives. It is as follows:

1. Literature survey, compiling the needs which have been published.
2. Contacts through industrial associations.
 - a. Correspondence with and visits to executive secretaries of groups such as American Drug Manufacturers Association, Plastic Materials Manufacturers Association, etc., relative to needs.
 - b. Attendance of meetings of cooperating groups, to contact leaders.
 - c. Listing of the best companies for detailed contacts from recommendations from a. and b.
3. Contacts with research institutes, universities doing industrial research, and government laboratories.
 - a. Correspondence
 - b. Visits to discuss needs that have been recognized
4. Organization of general information obtained in 2 and 3 in order to select obviously promising leads with chances of early results.
5. Visits to outstanding companies in each industry, with special attention to leads from 4.
 - a. Talks with technical men concerning recognized needs.
 - b. Talks with sales development groups concerning possible new products from new plants.
6. Summary of findings in a report, including recommendations for additional work.

This report is concerned only with items 2, 3, and 4; the initial steps in the direct-contact-with-industry phase of the program. The

literature survey is considered as a separate phase of the survey; consequently it is not reported here.

III. PROCEDURE

After reviewing publications^{1,2,3}, listing (1) national industrial associations, (2) research institutes, (3) universities, (4) research organizations and governmental laboratories, separate lists were compiled for initial correspondence in each of these four groups. Prospective contacts were initially selected on the basis of their known use of, or interest in, agricultural products. These primary lists were expanded to include all organizations in the four groups that could be reasonably assumed to use plant sources for raw material.

Letters of two types were individually prepared for distribution. Copies of these appear in the Appendix.

Answers were classified, according to interest expressed, in either an active or inactive file; in both cases suggested contacts were recorded. Interested replies were followed by additional correspondence, which in some cases led to personal contacts. Attempts were made to obtain statistical information concerning the needs suggested.

IV. RESULTS

Introductory letters were sent initially to 222 organizations; answers were received from 137. The breakdown by type of organization

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- (1) Judkins, J., National Associations of the United States. U.S. Department of Commerce, Washington, 1949.
 - (2) Hull, C., Handbook of Scientific and Technical Societies and Institutions of the United States and Canada. Fifth Edition. Bulletin of the National Research Council No. 115, Washington, 1948.
 - (3) Rand, M.J., Industrial Research Laboratories of the United States. Bulletin of the National Research Council No. 120, Washington, 1950.

is given in Table I. In the answers received, 31 different sources of information were suggested and subsequently contacted. Of the total 253 organizations written, answers have been received from 153. This represents a 60 per cent return on all correspondence. Personal interviews have been made with 20 organizations. From all contacts, both written and personal, 69 needs and 47 industrial organizations have been suggested as possible sources of information. Correspondence has been directed to those industries from which more detailed information has been received, and some personal contacts have been scheduled. The results of contacts with industrial organizations will be reported in detail at a later date.

TABLE I
SURVEY STATISTICS

<u>Organizations</u>	<u>Number Initial Contacts</u>	<u>Number Secondary Contacts</u>	<u>Total Number Contacts</u>	<u>Total Number Answers</u>
National Associations	75	21	96	52
University and Research Institutes	136	8	144	90
Governmental Laboratories	11	2	13	11
Totals	222	31	253	153

Table II is a compilation of all the needs suggested to date; they have been reported "as received," with no attempt having been made to trace the cause of the need to the raw material source. The statistics,

when given, have been compiled from publications of the Bureau of the Census^{4,5} and from values presented by organizations contacted. In some instances, substitutes for the needed material have been recommended; these are presented in Table III.

The following organizations have indicated that they will be pleased to cooperate, either through their scientific sections or member companies, in the evaluation of any raw materials developed under this program which fall in their respective fields:

1. Cigar Manufacturers Association of America, Inc., New York, N.Y.
2. Lee Foundation of Nutritional Research, Milwaukee, Wisconsin.
3. National Paint, Varnish and Lacquer Association, Washington, D.C.
4. New York Produce Exchange, New York, N.Y.
5. Northern Regional Research Laboratory, Peoria, Illinois.
6. Toilet Goods Association, Inc., New York, N.Y.

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- (4) Foreign Commerce and Navigation of the United States. U.S. Department of Commerce, Bureau of the Census, Washington, 1936-39 and 1946.
 - (5) United States Imports for Consumption of Merchandise. U.S. Department of Commerce, Bureau of the Census, Washington, 1947-50.

TABLE II

SUGGESTED RAW MATERIAL NEEDS
AND IMPORTS FOR CONSUMPTION

Need Suggested	Average Imports And Costs For 1936-1939		Average Imports And Costs For 1946-1950		Imports and Costs For 1950	
	Quantity* 1,000 lbs	Value* \$1,000	Quantity* 1,000 lbs	Value* \$1,000	Quantity* 1,000 lbs	Value* \$1,000
<u>Drying Oils</u>						
1. Linseed Oil.	334	17	57,173	13,267	68,861	13,372
2. Oiticica Oil	7,673	1,650	14,187	2,470	13,373	2,016
3. Perilla Oil.	61,150	3,258	0	0	0	0
4. Tung Oil	123,972	15,396	93,701	22,088	112,484	23,947
<u>Other Oils</u>						
5. Almond Oil ^a	117	90	112	84	26	30
6. Babassu Oil.	346	23	5,786	949	18,220	2,990
7. Coconut Oil ^b	340,044	12,966	77,561	12,590	137,744	20,549
8. Castor Oil ^c	218	12	14,539	2,077	46,590	5,724
9. Olive Oil ^d	152,786	19,486	36,272	11,947	88,951	20,612
10. Sesame Oil	15	1	428	105	248	50
11. Sunflower Oil.	12,401	408	105	11	0	0
12. Safflower Oil.	—	—	—	—	—	—

SUGGESTED RAW MATERIAL NEEDS
AND IMPORTS FOR CONSUMPTION

<u>Need Suggested</u>	<u>Average Imports And Costs For 1936-1939</u>		<u>Average Imports And Costs For 1946-1950</u>		<u>Imports and Costs For 1950</u>	
	<u>Quantity*</u> <u>1,000 lbs</u>	<u>Value*</u> <u>\$1,000</u>	<u>Quantity*</u> <u>1,000 lbs</u>	<u>Value*</u> <u>\$1,000</u>	<u>Quantity*</u> <u>1,000 lbs</u>	<u>Value*</u> <u>\$1,000</u>
<u>Essential Oils</u>						
13. Oil of Citronella	1,992	519	1,663	2,262	2,652	3,442
14. Oil of Lemon-Grass.	374	129	653	1,188	590	1,043
15. Oils of Labiatae and. Umbelliferae family	—	—	—	—	—	—
<u>Waxes and Gums</u>						
16. Candelilla Wax.	2,354	292	6,185	2,539	5,699	2,425
17. Carnauba Wax.	13,788	4,486	16,884	14,724	20,446	15,846
18. Karaya (and Talka).	6,287	659	7,342	1,643	8,205	1,951
19. Kauri	1,224	153	304	59	246	45
20. Shellac ^e	19,082	1,841	18,854	8,476	12,649	4,498
21. Lac	18,942	1,403	22,998	7,994	27,610	7,407
22. Tragacanth.	2,114	958	2,717	2,418	2,898	1,961
23. Beeswax (crudes).	4,318	950	4,849	2,241	5,733	2,520
24. Locust Bean Gum	2,749	342	6,325	1,522	10,974	2,548

(Continued)

TABLE II (Continued)

SUGGESTED RAW MATERIAL NEEDS
AND IMPORTS FOR CONSUMPTION

Need Suggested	Average Imports And Costs For 1936-1939		Average Imports And Costs For 1946-1950		Imports And Costs For 1950	
	Quantity* 1,000 lbs	Value* \$1,000	Quantity* 1,000 lbs	Value* \$1,000	Quantity* 1,000 lbs	Value* \$1,000
<u>Waxes and Gums (Cont.)</u>						
25. East India and Manila Gums	21,124	1,023	11,860	3,423	13,450	1,661
26. Montam Wax	0	0	1,137	270	2,238	422
<u>Fibers</u>						
27. Carpet Wool.	317,865	32,073	—	—	269,000**	215,000
28. Manila (or Abaca). . .	87,385	5,193	124,683	22,438	125,355	26,694
29. Sisal (or Henequen). .	273,517	11,723	278,918	32,100	342,180	38,560
30. Tampico.	18,473	635	21,157	1,740	20,729	1,732
31. Jute ^f	649,736	44,507	749,817	108,353	753,107	127,993
32. Felt Fibers.	—	—	—	—	—	—
33. Harsh Cotton	—	—	—	—	—	—
34. Fibers for Paper . . .	—	—	—	—	—	—
35. Wood Pulp Fibers . . .	—	—	—	—	—	—
36. Chrysotile Crudes. . .	12,940	941	34,586	3,153	30,184	3,941

SUGGESTED RAW MATERIAL NEEDS
AND IMPORTS FOR CONSUMPTION

<u>Need Suggested</u>	<u>Average Imports And Costs For 1936-1939</u>		<u>Average Imports And Costs For 1946-1950</u>		<u>Imports And Costs For 1950</u>	
	<u>Quantity*</u> <u>1,000 lbs</u>	<u>Value*</u> <u>\$1,000</u>	<u>Quantity*</u> <u>1,000 lbs</u>	<u>Value*</u> <u>\$1,000</u>	<u>Quantity*</u> <u>1,000 lbs</u>	<u>Value*</u> <u>\$1,000</u>
<u>Drugs and Pharma- ceuticals</u>						
37. Psyllium Seed. . . . (Blonde)	—	—	—	—	—	—
38. Digitalis.	45	9	23	8	6	1
39. Ergot.	181	225	174	203	—	—
40. Papain	—	—	349	1,041	229	365
41. Licorice Root. . . .	63,056	1,262	47,947	1,951	40,053	1,479
42. Atropine	—	—	—	—	—	—
43. Hyoscyamine.	—	—	—	—	—	—
44. Emetine.	—	—	—	—	—	—
45. Glutamine.	—	—	—	—	—	—
46. Levulose	—	—	—	—	—	—
47. Senna Leaves	1,942	88	1,900	178	1,374	97
48. Menthol ^g	403	939	447	3,196	501	4,549
49. Agar Agar.	604	351	315	441	649	464

(Continued)

TABLE II (Continued)

SUGGESTED RAW MATERIAL NEEDS
AND IMPORTS FOR CONSUMPTION

<u>Need Suggested</u>	<u>Average Imports And Costs For 1936-1939</u>		<u>Average Imports And Costs For 1946-1950</u>		<u>Imports and Costs For 1950</u>	
	<u>Quantity*</u> <u>1,000 lbs</u>	<u>Value*</u> <u>\$1,000</u>	<u>Quantity*</u> <u>1,000 lbs</u>	<u>Value*</u> <u>\$1,000</u>	<u>Quantity*</u> <u>1,000 lbs</u>	<u>Value*</u> <u>\$1,000</u>
<u>Drugs and Pharmaceu- ticals (Cont.)</u>						
50. Steroids	--	--	--	--	--	--
51. Betaine.	--	--	--	--	--	--
52. Inositol	--	--	--	--	--	--
53. Tryptophane.	--	--	--	--	--	--
<u>Miscellaneous</u>						
54. Lime Oil	--	--	--	--	--	--
55. Rubber Latex	46,155	7,878	62,844	17,727	115,644	39,717
56. Pepper ^h	58,727	2,911	28,386	20,574	33,157	47,364
57. Guar Flour	--	--	--	--	--	--
58. Red Squill	--	--	334	24	535	33
59. Sabadilla Seed	--	--	--	--	--	--
60. Tannin	--	--	--	--	--	--
61. Pyrethrum.	14,989	2,203	10,121	2,738	8,266	2,606

SUGGESTED RAW MATERIAL NEEDS
AND IMPORTS FOR CONSUMPTION

Need Suggested	Average Imports And Costs For 1936-1939		Average Imports And Costs For 1946-1950		Imports And Costs For 1950	
	Quantity* 1,000 lbs	Value* \$1,000	Quantity* 1,000 lbs	Value* \$1,000	Quantity* 1,000 lbs	Value* \$1,000
<u>Miscellaneous (Cont.)</u>						
62. Amylose	—	—	—	—	—	—
63. Alcohol-Soluble Protein	—	—	—	—	—	—
64. Lysine.	—	—	—	—	—	—
65. Methionine.	—	—	—	—	—	—
66. Disease-Resistant Tobacco	—	—	—	—	—	—
67. Better Leaf Tobacco . .	—	—	—	—	—	—
68. Dispersion of growing . Area of Connecticut Leaf Tobacco	—	—	—	—	—	—
69. Plants which produce Fats and Starches in the Body of the Plant	—	—	—	—	—	—
(a) Sweet and Bitter	*Quantity is expressed in thousands of pounds and value in thousands of dollars.					
(b) Crude and Refined						
(c) Crude, Dehydrated, and Sulfonated	**This figure includes the time from July 1, 1949, to July 1, 1950. The price is an approximate value.					
(d) Edible, Inedible, and Sulfur Foots						
(e) Bleached and Unbleached						
(f) Unmanufactured and Products						
(g) Natural and Synthetic						
(h) Black and White, Ground and Unground						

TABLE III
SUGGESTED NEW RAW MATERIAL SOURCES

<u>Item</u>	<u>Suggested New Raw Material Sources</u>
Tannin	Cascalote Bean Pala Blanco Bark Canagrie
Gum Tragacanth	Carob Bean
Perilla Oil	Chia Oil
Tung Oil	Gracia Nutans Oil
Waxes	Jojoba Nut Myrtle Wax Laurel Berry Wax
Ergot	Certain Species of Mushroom
Paper Making Pulp	Japanese Paste Hemp
Deflocculating Mucilage	Japanese Paste Hemp

V. DISCUSSION OF RESULTS

A. Analysis of Effectiveness of Method

From Table I it can be seen that about 60 per cent of the letter inquiries were answered. The number of contacts suggested in these letters, however, was disappointing. Possible explanations for this might be:

1. The initial letters were improperly composed.
2. The letters may not have received the attention of the proper people in the organization.
3. Lack of interest by the organization contacted in a project of this type.
4. The nature of the problem may be such that the results obtained are all that could be expected from the organizations contacted.

The first reason would appear to be ruled out as a major cause, since a 60 per cent return was obtained for all correspondence. From general observations, the writer is inclined to favor the third reason as a strong contributing factor. Letters were received which plainly stated a lack of interest. Many other organizations which were expected to have needs or problems answered with a brief negative or not at all. Although some contacts expressed considerable interest, they offered no problems or suggestions. The other two reasons are difficult to evaluate. Many factors probably contribute to the problem, but it is believed that the last two reasons mentioned are the major causes in the decline of the total number of possible contacts. If this is true, the low number of suggested contacts precludes a fault in the method; i.e., as much as could be expected has been obtained from the organizations contacted. The number of industrial contacts will be expanded by direct contact with approximately 800 companies.

The personal contacts have in the majority of cases yielded definite information. The receptions have been cordial and the attitudes, cooperative. It is of interest to note that individuals interviewed have stated that they would give detailed information verbally but would not consider correspondence as a medium for conveying details. The value of personal contact to this work should definitely be emphasized as the project is continued.

B. Discussion of Suggested Needs

Sufficient information is not available to discuss adequately all of the needs listed in Table II. Consequently, the following discussion is limited to a few items in several fields of interest and should be

considered as preliminary, with more detailed information to be reported at a later date.

1. Drying Oils

The protective coating industry has experienced supply difficulties with drying oils for a number of years. The present desires include a replacement for tung oil, which has a fluctuating supply and price history. Oil of Garcia Nutans is of the tung type and has been recommended by the paint industry as a possible tung substitute. This oil could be used as a replacement for tung up to 100 per cent if it could sell slightly under the market price for tung. The present price for tung oil is \$0.35 per pound. Another drying oil of considerable interest to this industry is chia oil (Salvia Hispanica). This oil is of the Perilla type and could be substituted in formulations requiring Perilla. Perilla oil formulations for some uses possess some superior properties over other formulations. Consequently, since Perilla has not been available since 1946, the protective coating industry would like to see chia or Perilla developed domestically as a source of this type of drying oil. It is estimated that 60 million pounds of this oil would be consumed in this country annually at the market price of linseed oil. The price of linseed oil is subject to fluctuation and has varied from a low of about \$0.05 per pound during the period 1936-1939 to the present price of \$0.17 per pound.

Another drying oil which has created much interest in the paint industry is safflower oil. The paint industry provides a ready market for this material and awaits its appearance on the market in sufficient quantities to make changes in formulation economically feasible.

2. Essential Oils

Of the essential oils needed, the two most important, based on volume used, which require supplements or domestic sources are oil of citronella and oil of lemon-grass. Citronella has widespread use as a starting material in the synthesis of several organic compounds, one of which is menthol. The oil of lemon-grass supply situation has been complicated by the new use of this material as the raw material in the synthesis of Vitamin A. The main concerns with both of these oils are the fluctuating supply and price. Some users of oil of lemon-grass would pay up to a ten per cent premium above the market price for this oil if an adequate domestic source were available, since they would be assured of a stable source of supply of both quantity and quality. The present consumption of oil of lemon-grass is about 600,000 pounds per year. It has been estimated that this figure could be doubled by a reduction in price from the present approximate \$4.00 per pound to about \$1.25 per pound. A reduction in price of citronella from the present approximate \$2.00 per pound to \$1.00 per pound would approximately double the 2.5 million pounds now consumed.

The other essential oils of interest are those of the Labiatae and Umbelliferae families and oil of lime. The volume of these is relatively small but their uses are widespread and important. The present price of oil of lime at \$8.00 per pound is prohibitive. A more abundant supply would reduce this price and greatly increase the utilization.

3. Other Oils

Much concern has been expressed concerning lauric acid and ricinoleic acid oils. This country experienced great difficulty in obtaining these materials during World War II. This factor, combined

with present price and duty figures, has led to great interest by large volume users in a domestic source of supply. The castor bean program should appreciably alleviate the difficulty as regards ricinoleic acid oils, but apparently little has been done about the lauric acid oils situation. Coconut and babassu oil can be classed as major imports to this country; the annual consumption approaches 156 million pounds at a cost of 24 million dollars. Any lauric acid oil produced in this country which could compete with the import price for coconut and babassu would find a receptive market. Some interest has been expressed by the nutritional field in sesame and sunflower oil and cake. The markets for these materials are available provided that they could compete economically with cottonseed oil and cake. The present price for cottonseed oil is \$0.15 per pound.

4. Fibers

In recent years the decrease in the world's production of wool has caused the wool-consuming industries considerable difficulty. The carpet industry, as a large user, is interested in the development of fibers as substitutes for carpet wool. Rayon has been employed as a replacement for wool in carpet manufacture, but the short supply of this material has forced the use of cotton as a last resort. The carpet industry now uses 250 million pounds per year of carpet wool. If replacement fibers were available, the industry could use 80 million pounds. Other fibers of particular interest include all of the hard-type fibers. The primary one in this category is jute. The uses for this material are increasing and the supply cannot meet the demand. The statistics indicate 753 million pounds of jute imported in 1950. This corresponds to an annual value of approximately 128 million dollars. Any fiber

comparable to jute which could be produced in this country would find a ready market.

The manufacturers of asbestos textiles have expressed the desire for an organic fiber which would lend itself to flame proofing. Such a fiber might be used as a replacement for chrysotile fibers in asbestos products which are not required to meet underwriters' grade. This substitution could free the long chrysotile fiber now used for asbestos tile, pipe, etc., for use as textile raw material. The 1950 import of chrysotile crudes was 30 million pounds at a value of approximately four million dollars. Additional investigation will be required, however, to determine the quantity and possible price of the suggested substitute fiber that might be used.

The need for papermaking and insulation-type cellulose fibers has been established in the past. It seems appropriate, however, to emphasize here the need for a crop to produce cellulose fiber material at several times the present rate, i.e., a crop which would annually yield several times more fibers per acre than present sources. The cellulose processing industries have suggested faster growing trees and/or a perennial plantation-type crop to fill the ever increasing need for cellulose fiber.

5. Waxes and Gums

Waxes and gums have many critical uses in the present industrial structure and, consequently, are of concern to processors in several fields. These materials with some exceptions are imported into this country. The major import in this category is carnauba wax. The annual importation has been approximately 20 million pounds per year at about \$0.75 per pound. Other waxes of interest are candelilla and beeswax.

Candelilla has been used as a diluent in carnauba; this use should increase as long as the carnauba price is at its present level of about \$1.25 per pound.

The gums which have been classed as needs are tragacanth and locust bean gum. The situation with regard to these materials is one of inadequate supply and varying price. The present price of tragacanth, about \$4.00 per pound, has forced users to search for substitutes as diluents. The use of locust bean gum is continually increasing. In the past 15 years the quantity of this material imported has increased from about three million pounds per year to approximately 11 million pounds per year. The price has increased during this period from \$0.12 per pound to the present figure of about \$0.45 per pound.

Suggested sources of waxes are the myrtle, the laurel berry, and the jojoba nut. Jojoba, or Simmondsia, nut wax has been suggested as a source for a high temperature lubricant. After hydrogenation this material forms a hard wax, slightly softer than carnauba, which might be used as a carnauba replacement. The plant already grows wild in the southwest; however, the introduction of specimens from Asia might assist in the development of plants suitable for large-scale mechanical cultivation and harvesting.

6. Drugs and Pharmaceuticals

To a large extent the United States depends on imports for its drug and pharmaceutical raw materials. These items considered on a monetary or volume basis, are relatively small; however, many of these materials are of vital importance to the national welfare. Others are of interest from the viewpoint of possible extension of use, which usually depends on achieving a lower unit price for the commodity.

Those of importance to national welfare are ergot, digitalis, senna leaves, papain, licorice root, atropine, hyoscyamine, and emetine. Some relief from the ergot deficit seems possible if the University of Florida's mushroom program is successful. Supplies of the rest, however, will apparently remain critical as long as trade difficulties exist and demands remain high. In the second category can be listed blonde psyllium seed (Plantago Ovata), levulose, and glutamine. It has been estimated that the volume of Ovata consumed could be increased to 30 million pounds per year if available at \$0.06 per pound. Recent market fluctuations have changed the price from \$0.10 to \$0.21 per pound. This material has some unique gelatinous properties which would find widespread adoption if a stable domestic source could be developed.

Levulose, aside from some of its established uses, would find a ready market as a sugar for diabetics if the present prohibitive price of \$11.00 per pound could be reduced to about \$2.00 per pound. It has been estimated that diabetics would consume approximately two pounds per month per person of this material and would be delighted, of course, to have a source of sugar which could be tolerated. If the price of levulose were reduced to 1.7 times that of sucrose it could become competitive on the sugar market. This seems evident since levulose possesses a "sweetening" power 1.7 times that of sucrose.

Glutamine is a rare chemical which has been reported by one organization to be useful as a blood buffer. This material would be valuable in blood substitute preparations. The present price of \$2,500 per pound, when it is at all available, has retarded extensive research in the evaluation of this material. A reasonable source of supply of

this material might conceivably pave the way for more effective blood substitute preparations.

7. Miscellaneous

a. Tannin. The need for new domestic sources of tannin has been established for a number of years. The program underway at present should provide sources of this type of material; however, two sources have been suggested; the cascalote bean of Mexico, and palo blanco bark which is indigenous to Mexico and the southwest. Domestic sources of tannin materials are definitely needed as emergency standbys, even if they cannot compete economically with imports.

b. Pepper. The continual demand for black pepper and the diminished sources of supply have caused the price of this commodity to rise to its present price of about \$1.67 per pound. The hand labor required in the cultivation and harvesting of this material has discouraged extensive development of this crop in the United States. If plants could be developed which would lend themselves to domestic cultivation and large scale mechanical handling, a pepper industry in this country could be successful. The present price of about \$1.67 per pound, with a volume of approximately 30 million pounds per year, indicates a ready market for the product.

c. Amylose. Amylose has important industrial possibilities. It would serve as an important industrial raw material if a satisfactory source could be developed. Specifically, what is needed is a plant which would contain a high concentration of amylose. When extracted from the plant, amylose could be made into films and fibers which have some unique properties.

d. Tobacco. The cigar manufacturers are concerned with two problems. First, the attack of a disease, such as black shank, on tobacco results in a lower quality leaf sold at a higher price which is ultimately passed on to the consumer. This is particularly true with the Georgia-Florida, and Connecticut shade-grown, wrapper-leaf tobacco. Disease resistant strains would greatly improve this situation. Second, the present source of binder-leaf cigar tobacco comes almost entirely from a small area in Connecticut. A failure of this crop for two years in succession would ruin the cigar industry. The organization representing cigar manufacturers has suggested that attempts be made to disperse the Connecticut binder-leaf type to other growing areas in the country.

e. New Source of Fats. Several recommendations have been made for the introduction or development of plants which produce fats or oils in the vegetative parts of the plant, i.e., plants which would accumulate fats or oils in the body of the plant as sugar cane accumulates sugar. Such a plant should greatly increase the yield of fat or oil per acre and, consequently, reduce the cost per unit the world over. Without consideration for the practicability of this suggestion, it should be classed as a challenging need which modern plant science should be able to fill.

C. Industrial Organizations Suggested for Contact

The list of industrial concerns given in Table IV has been compiled from suggestions given by organizations contacted. They represent the companies which have specific interest in one or more of the listed needs. Contact with these industrial organizations should provide more detailed information on these commodities; in turn, the data should provide a more comprehensive analysis of the raw material needs of this country.

TABLE IV

LIST OF COMPANIES SUGGESTED FOR CONTACT

American Brake Shoe Company, Detroit, Michigan
Armstrong Cork Company, Lancaster, Pennsylvania
Davies-Young Soap Company, Dayton, Ohio
L. A. Dreyfus Company, Oak Tree, New York
Flinkote Company, Los Angeles, California
Fritzsche Brothers, Inc., New York, N.Y.
Givaudan-Dellawanna, Inc., Dellawanna, New Jersey
William J. Hale, Midland, Michigan
W. C. Hamilton and Sons, Miquon, Montgomery County, Pennsylvania
Hefco Laboratories, Detroit, Michigan
Hollingsworth and Vose Company, East Walpole, Massachusetts
J. L. Hopkins Company, Brooklyn, New York
Johnson-Salisbury, Inc., New York, N.Y.
The Kay and Ess Company, Dayton, Ohio
Lever Brothers, New York, N.Y.
John A. Manning Paper Company, Inc., Troy, New York
National Drug Company, Philadelphia, Pennsylvania
John Powell and Company, Inc., New York, N.Y.
Raybestos-Manhattan, Inc., Manheim, Pennsylvania
Schering Corporation, Bloomfield, New Jersey
Scientific Associates, St. Louis, Missouri
Stein, Hall and Company, Inc., New York, N.Y.
Thompson and Company, Oakmont, Pennsylvania
Valentine Company, Richmond, Virginia
Weyerhaeuser Timber Company, Longview, Washington
Wood Conversion Company, Cloquett, Minnesota

VI. CONCLUSIONS AND RECOMMENDATIONS

The method of correspondence used for the survey has been satisfactory, and personal interviews with organization leaders have been successful and informative. This survey should be continued, using the same method; emphasis should be given to personal interviews with industrial leaders.

The information reported indicates that the raw material needs can be classified into the following categories:

1. Oils
2. Fibers
3. Drugs and pharmaceuticals
4. Waxes and gums
5. Miscellaneous material.

The results reported must be considered preliminary, but the data indicate the most critical needs to be hard fibers, oils, and several drugs such as ergot and atropine. These items, as well as most of the other listed needs, have been so classified by organizations because of supply deficits or prices which are incompatible with the present price structure.

A compilation of data on the consumption of industrial raw materials is recommended, since the data would indicate volume and price figures. This information would be valuable as an economic guide. A survey of imports for consumption itemized by country and commodity should also be useful, since it might produce leads to raw material needs.

The industries suggested by the cooperating organizations should be listed in one of the general categories according to the raw materials used. They should be contacted by correspondence and interested

organizations interviewed. Correspondence should also be directed to approximately 800 additional companies, selected from the literature,⁵ which use raw materials which have been classed as needs; interested organizations should be interviewed. This procedure is being followed at present to insure maximum coverage of industry; complete results should present a representative picture of the industrial raw material needs of this country.

Respectively submitted:

H. H. Sineath *by HHC*
Assistant Project Director

Approved:

Herschel H. Cudd
Project Director

Gerald A. Rossélot, Director
State Engineering Experiment Station

(5) Rand, M. J., op.cit.

VII. APPENDIX

The following is a copy of the text of the letter sent to industrial institutes, government laboratories and universities doing research:

Dear :

We are presently attempting to compile information on the needs of industry for raw materials from new plants which could be grown in the United States. This work is being done for the Bureau of Plant Industry of the U.S. Department of Agriculture, and will serve as a guide in the search for new plants and for new plant uses.

Specifically, we are requesting that you forward to us any information of raw material needs known to you, to members of your group, or which might have developed out of research undertaken by your organization.

We are interested in either an affirmative or a negative response; however, in the event that you are able to suggest needs, we would welcome the opportunity of meeting with you or your associates if it can be arranged. If you are unable to convey such needs, is it possible that you could refer us to someone who might have information of this type?

We will appreciate your consideration of this matter and will look forward to hearing from you.

Yours very truly,

H. H. Sineath

The following is a copy of the text of the letter sent to associations:

Dear :

Industrial concerns with which you have had contact have, perhaps, experienced either present shortages of, or long-range needs for new sources of raw materials. These deficiencies are of concern to us in that we are attempting to compile information on the needs of these industries for raw materials from new plants which could be grown in the United States. These data will serve as a guide in the search for plants which will provide supplements to present sources of raw materials.

Specifically, we are requesting that you forward to us information of any raw material shortages or needs which now exist or which are anticipated in the future.

We are interested in either an affirmative or a negative response; however, in the event that you are able to suggest needs of these industries, we would welcome the opportunity of meeting with you or representatives of the organizations concerned. If you are unable to suggest such needs, is it possible that you could refer us to someone in your field who might have information of this type?

We will appreciate your consideration of this matter and will look forward to hearing from you.

Yours very truly,

H. H. Sineath

Georgia Institute of Technology
STATE ENGINEERING EXPERIMENT STATION
Atlanta, Georgia

PHASE REPORT NO. 3

PROJECT NO. 177-120

SURVEY OF THE NEEDS OF INDUSTRY
FOR
RAW MATERIALS FROM NEW PLANTS
TO BE
GROWN IN THE UNITED STATES

By

H. H. SINEATH

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CONTRACT NO. A-1S-33022

DIVISION OF PLANT EXPLORATION AND INTRODUCTION
BUREAU OF PLANT INDUSTRY
UNITED STATES DEPARTMENT OF AGRICULTURE

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JANUARY 22, 1952

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This report contains 43 pages

I. SUMMARY

This report presents the results of the direct-contact-with-industry phase of a survey to determine the needs of industry in the United States for raw materials from plant sources. The project was instigated by C. O. Erlanson, Head of the Division of Plant Exploration and Introduction of the Bureau of Plant Industry of the United States Department of Agriculture.

Contacts were made by correspondence with industries suggested by research organizations and industrial associations and with approximately 700 other companies selected from the literature. Personal interviews were conducted with representatives of cooperating industrial organizations.

The method used for the survey has been considered satisfactory and is recommended for future surveys of this type. The most critical needs found were in the fiber, oil, and drug fields.

Extensive conclusions and recommendations for future work will be presented in the final report, but the results of this phase of the survey indicate that the continuation of this work would be valuable to the Sponsor.

II. INTRODUCTION

At the instigation of its Head, C. O. Erlanson, the Division of Plant Exploration and Introduction requested in February, 1951, that the Georgia Institute of Technology make a survey of the needs of industry for raw material from plant sources. For the purpose of reporting the

results of this survey, the proposed program was divided into three phases. Phase Report No. 1, which covered the initial steps in the direct-contact-with-industry phase of the program, was submitted on July 16, 1951. The reported results, which were based on information obtained from research organizations and industrial associations, indicated that the survey should be continued and should include contact with individual companies. This report is concerned with this contact-with-individual-companies phase of the program and has been called phase three.

A literature survey of published needs (phase two) has been conducted concurrently with phases one and three and the results obtained will be submitted in a separate report.

III. PROCEDURE

The industries suggested by organizations contacted in phase one and approximately 700 additional companies selected from the literature¹ were listed for contact. Companies that could reasonably be assumed to use plant sources of raw materials were included. A copy of the letter which was distributed to these companies is included in the Appendix. Answers were classified according to the interest expressed, and companies recommended for contact were written. The replies from all of these organizations were placed in either an active or an inactive category. Additional correspondence was directed to organizations in the active category, and personal interviews were conducted in some cases. Attempts were made to obtain statistical information concerning the needs suggested.

¹ - - - -
Rand, M.J., Industrial Research Laboratories of the United States.
Bulletin of the National Research Council No. 120, Washington, 1950.

IV. RESULTS

A. Scope of Survey

Letters were sent to 758 industrial organizations; answers were received from 454. This represents a 60 per cent return on all correspondence. Personal interviews have been made with representatives of 37 companies. From all contacts, both written and personal, 189 raw material needs have been suggested. These raw materials have been classified into the following groups:

1. Oils
2. Fibers
3. Drugs and Pharmaceuticals
4. Waxes, Gums, and Resins
5. Miscellaneous Materials

B. Tables

Table I is a compilation of significant raw material needs. The statistics given in the first two columns of Table I have been compiled from publications of the Bureau of the Census^{2,3} and the Office of Foreign Agricultural Relations.⁴ Other statistics are estimates which are based on information received from the survey and should be construed as the writer's interpretation of these data.

² - - - - -
United States Imports for Consumption of Merchandise. U.S. Department of Commerce, Bureau of the Census, Washington, 1947-50.

³Foreign Commerce and Navigation of the United States. U.S. Department of Commerce, Bureau of the Census, Washington, 1936-39 and 1946.

⁴Foreign Agricultural Trade. Office of Foreign Agricultural Relations, U.S. Department of Agriculture, Washington, December, 1950.

TABLE I

SUGGESTED RAW MATERIAL NEEDS WITH IMPORTS FOR
CONSUMPTION AND ESTIMATED VOLUME AND PRICE NEEDED

<u>Needs Suggested</u>	<u>Imports for Consumption and Price for 1950</u>		<u>Estimated Volume and Price Needed</u>	
	<u>Quantity in Thousands of Pounds</u>	<u>Price in Dollars Per Pound</u>	<u>Quantity in Thousands of Pounds</u>	<u>Price in Dollars Per Pound</u>
<u>Drying Oils</u>				
1. Castor Oil	178,703 ^{a,b}	.12 ^c	200,000	.12
2. Tung Oil	112,484	.21	125,000	.20
3. Perilla Oil.	--	--	60,000	.18
4. Safflower Oil.	--	--	60,000	.18
<u>Essential Oils</u>				
5. Oil of Anise	275 ^d	1.06 ^c	--	--
6. Oil of Citronella. . . .	2,652	1.30	4,000	1.00
7. Oil of Coriander	1,610	.08	--	--
8. Oil of Lemon-Grass . . .	590	1.77	1,000	1.30
9. Oil of Lime.	259	5.14	300	4.00

(Continued)

TABLE I (Continued)

SUGGESTED RAW MATERIAL NEEDS WITH IMPORTS FOR
CONSUMPTION AND ESTIMATED VOLUME AND PRICE NEEDED

Needs Suggested	Imports for Consumption and Price for 1950		Estimated Volume and Price Needed	
	Quantity in Thousands of Pounds	Price in Dollars Per Pound	Quantity in Thousands of Pounds	Price in Dollars Per Pound
<u>Other Oils</u>				
10. Babassu Oil	38,891 ^e	.16	- -	- -
11. Coconut Oil	726,000 ^f	.15 ^c	850,000 ^g	.15
12. Olive Oil (Edible). . . .	79,288 ^h	.24	- -	- -
13. Palm Oil.	56,400	.11	80,000	.10
14. Palm Kernel Oil	19,760	.14	- -	- -
15. Sesame Oil.	9,951 ⁱ	.20 ^c	- -	- -
16. Sperm Whale Oil	46,075 ^j	.10	- -	- -
17. Sunflower Oil	73 ^k	.32 ^l	- -	- -

(Continued)

TABLE I (Continued)

SUGGESTED RAW MATERIAL NEEDS WITH IMPORTS FOR
CONSUMPTION AND ESTIMATED VOLUME AND PRICE NEEDED

<u>Needs Suggested</u>	<u>Imports for Consumption and Price for 1950</u>		<u>Estimated Volume and Price Needed</u>	
	<u>Quantity in Thousands of Pounds</u>	<u>Price in Dollars Per Pound</u>	<u>Quantity in Thousands of Pounds</u>	<u>Price in Dollars Per Pound</u>
<u>Fibers</u>				
18. Abaca	123,115	.22	--	--
19. Asbestos.	--	--	--	--
20. Carpet Wool	269,000 ^m	.60	330,000	.50
21. Cellulose Fibers.	--	--	--	--
22. "Harsh" Cottons	25,340 ⁿ	.24	28,500	.19
23. Jute.	730,000 ^o	.17	900,000	.15
24. Long Staple Cotton.	63,308 ^p	.48	65,000	.45
25. Ramie (Raw).	Negligible	--	--	--
26. Sisal (Raw)	342,180	.11	--	--

(Continued)

TABLE I (Continued)

SUGGESTED RAW MATERIAL NEEDS WITH IMPORTS FOR
CONSUMPTION AND ESTIMATED VOLUME AND PRICE NEEDED

<u>Needs Suggested</u>	<u>Imports for Consumption and Price for 1950</u>		<u>Estimated Volume and Price Needed</u>	
	<u>Quantity in Thousands of Pounds</u>	<u>Price in Dollars Per Pound</u>	<u>Quantity in Thousands of Pounds</u>	<u>Price in Dollars Per Pound</u>
<u>Drugs and Pharmaceuticals</u>				
27. Belladonna (Atropine)	357	.27	360	.27
28. Cortisone (Other Steroids . . for Hormone Starters)	--	--	--	--
29. Ergot	151 ^q	4.04 ^r	250	3.75
30. Khellin (<u>Ammi visnaga</u>). . . .	--	--	--	--
31. Menthol	501	9.08	600	8.50
32. Papain.	230	1.60	500	1.60
33. <u>Plantago ovata</u>	3,288	.29 ^s	--	--

(Continued)

TABLE I (Continued)

SUGGESTED RAW MATERIAL NEEDS WITH IMPORTS FOR
CONSUMPTION AND ESTIMATED VOLUME AND PRICE NEEDED

<u>Needs Suggested</u>	<u>Imports for Consumption and Price for 1950</u>		<u>Estimated Volume and Price Needed</u>	
	<u>Quantity in Thousands of Pounds</u>	<u>Price in Dollars Per Pound</u>	<u>Quantity in Thousands of Pounds</u>	<u>Price in Dollars Per Pound</u>
<u>Waxes, Gums, and Resins</u>				
34. Candelilla	5,699	.43	8,000	.40
35. Carnauba	20,446	.78	- -	- -
36. Guar	- -	- -	- -	- -
37. Karaya	8,172	.24	10,000	.20
38. Latex.	115,644	.34	- -	- -
39. Locust Bean Gum.	10,974	.23	- -	- -
40. Tragacanth	2,898	.68 ^t	3,500	.65 ^t

(Continued)

TABLE I (Continued)

SUGGESTED RAW MATERIAL NEEDS WITH IMPORTS FOR
CONSUMPTION AND ESTIMATED VOLUME AND PRICE NEEDED

<u>Needs Suggested</u>	<u>Imports for Consumption and Price for 1950</u>		<u>Estimated Volume and Price Needed</u>	
	<u>Quantity in Thousands of Pounds</u>	<u>Price in Dollars Per Pound</u>	<u>Quantity in Thousands of Pounds</u>	<u>Price in Dollars Per Pound</u>
<u>Miscellaneous Materials</u>				
41. Bristles	7,357 ^u	3.85	8,000	3.50
42. Cork	51,396 ^v	.05	--	--
43. Cube (Rotenone Source) . . .	9,750	.10	--	--
44. Pepper	33,156 ^w	1.43	43,000	1.00
45. Pyrethrum.	8,268	.32	12,000	.30
46. Ryania	--	--	--	--
47. Sabadilla.	--	--	--	--
48. Tannin and Tanning Materials	--	--	--	--
49. Zein	--	--	--	--

(Continued)

TABLE I (Continued)

SUGGESTED RAW MATERIAL NEEDS WITH IMPORTS FOR
CONSUMPTION AND ESTIMATED VOLUME AND PRICE NEEDED

^aOil and oil equivalent of beans (50 per cent oil in bean). Includes oil imported for all purposes.

^bApproximately 34 million pounds of oil are expected to be produced domestically in 1951, according to William H. Shearon, "Vegetable Oils." Chemical and Engineering News 29, 4068 (October 1, 1951).

^cPrice calculated from oil imports

^dOil and oil equivalent of seed (2.5 per cent oil in seed).

^eOil and oil equivalent of kernels (62 per cent oil in kernel).

^fTotal oil and oil equivalent. (Assume 63 per cent recovery from copra.)

^gThis volume is based on the total need for lauric acid oils, including coconut, babassu, and palm kernel oils.

^hInedible imports amounted to about 8,760,000 pounds.

ⁱOil and oil equivalent (47 per cent oil from seed).

^jCrude and refined.

^kOil equivalent of seed (based on 25 per cent oil in seed).

^lEstimated from seed cost.

(Concluded)

TABLE I (Concluded)

SUGGESTED RAW MATERIAL NEEDS WITH IMPORTS FOR
CONSUMPTION AND ESTIMATED VOLUME AND PRICE NEEDED

^mThis figure includes imports from July 1, 1949-July 1, 1950. The price is an approximate figure.

ⁿIndian and Peruvian staple under 1-1/8 inches.

^oBoth unmanufactured and finished products.

^pStaple over 1-1/8 inches.

^qIncludes estimated domestic production obtained from Bureau of Agricultural Economics.

^rBased on imports.

^sQuantity includes blond seed and husk so that the price is not representative.

^tAverage for all grades.

^uSorted, bunched, prepared, and crude.

^vCrude bark or wood and bark cut in squares.

^wBlack and white, ground and unground.

Information on the effect of price on volume has not been included in the report. These data will be reported for the items selected for detailed market surveys.

Raw materials which come from plants, or which might conceivably come from plants, have been classed as needed if they are included in one or more of the following categories:

1. The supply is inadequate on a volume basis only.
2. The materials are available at prohibitive prices.
3. They are imported materials which might be affected by international trade difficulties or for which a more stable purity is desired.

On a monetary or volume basis some items included in Table I are of little significance, but they have been included because of their apparent importance to the national health and welfare.

During the investigation, representatives from various organizations have suggested substitutes or new sources for needed raw materials. These have been listed in Table II without consideration for their economic or technological feasibility.

A list of the companies which have offered to cooperate in the evaluation of raw materials investigated is given in Table III. These organizations are listed alphabetically and comments are given concerning their specific fields of interest.

Table IV, which is included in the Appendix, contains a list of all suggested raw material needs which have not been included in Table I.

TABLE II

SUGGESTED RAW MATERIAL SOURCES OR SUBSTITUTES

Source or Suggested Item	Comments
<u>1. Oils</u>	
<u>Drying Oils</u>	
Chia (<u>Salvia hispanica</u>)	Source of perilla-type oil
Chinese Tallow Nut	Source of drying oil
<u>Garcia nutans</u>	Source of substitute for tung oil
Ilera or Monila	Source of drying oil
<u>Other Oils</u>	
<u>Simmondsia</u> -Seed Oil	Substitute for sperm whale oil
<u>Picramnia</u>	Source of <u>Tariri</u> fat
<u>2. Fibers</u>	
Bamboos	Source of fiber
Kenaf	Source of fiber
<u>Sansevieria</u>	Source of fiber
<u>3. Drugs and Pharmaceuticals</u>	
<u>Clitocybe subilludens</u>	Source of ergot-like drug
Curare	Contains a tubocurine chloride
Dioscorea	Source of diosgermin
<u>Oplapanex horridus</u>	Source of antidiabetic agent
Fig (Proteolytic Enzyme Ficin)	Source of proteolytic enzymes
<u>Stephania cephalantha</u> and <u>sasakii</u>	Source of drug reported as being useful in treatment of tuberculosis and leprosy

(Continued)

TABLE II (Continued)

SUGGESTED RAW MATERIAL SOURCES OR SUBSTITUTES

<u>Source or Suggested Item</u>	<u>Comments</u>
<u>Drugs and Pharmaceuticals</u> <u>(Continued)</u>	
<u>Rauwolfia serpentina</u>	Contains antihypertension agent
<u>4. Waxes, Gums, and Resins</u>	
<u>Simmondsia Wax</u>	Source of industrial wax
<u>5. Miscellaneous Materials</u>	
Barbasco Root	Source of rotenone
Canaigre	Source of tannin
Creosote Bush	Source of rotenone
Stinkweed	Source of rotenone
Sumac	Source of tannin

TABLE III

LIST OF COMPANIES OFFERING EVALUATION SERVICES

Name and Address of Company	Comments
1. Archer, Daniels, Midland Co. Cleveland, Ohio	Offered evaluation services for non-oxidizing oils. Primary interest in <u>Simmondsia</u> -seed oil.
2. Armstrong Paint and Varnish Works Chicago, Illinois	Will evaluate drying oils.
3. Champion Paper and Fibre Co. Hamilton, Ohio	Interested in fibers for paper-making and have offered evaluation service for this purpose.
4. Devoe and Reynolds Company Louisville, Kentucky	Will evaluate drying oils and bristles for paint brushes.
5. Emery Industries, Inc. Cincinnati, Ohio	Offered to evaluate <u>Tariri</u> fat and <u>Simmondsia</u> -seed oil.
6. General Bio-Chemicals, Inc. Chagrin Falls, Ohio	Will evaluate on 60,000 pounds per month scale non-saponifiable vegetable oils.
7. Irvington Varnish and Insulator Company Irvington, New Jersey	Evaluation service for drying oils.
8. Minnesota Mining and Manufacturing Company Saint Paul, Minnesota	Interested in substitutes for wood pulps, resins, and plasticizers and will evaluate these items.
9. Polymer Industries Astoria, New York	Offered to evaluate gums of locust bean and guar types.
10. John Powell and Co., Inc. New York, New York	Will evaluate insecticides and synergist.
11. G.D. Searle and Company Chicago, Illinois	Would like domestically produced <u>Plantago ovata</u> and steroid starting material and offered evaluation service for these materials.

(Continued)

TABLE III (Continued)

LIST OF COMPANIES OFFERING EVALUATION SERVICES

Name and Address of Company	Comments
12. Thompson and Company Oakmont, Pennsylvania	Offered evaluation service for materials in the industrial and technical paint field.
13. United Fruit Company Boston, Massachusetts	Will cooperate in the introduction of new crops into Central America and will supply seeds now grown in their experimental operations.

V. DISCUSSION OF RESULTS

A. Discussion of Method

A review of the survey statistics given in the results indicates that about 60 per cent of the letter inquiries were answered, and about eight per cent of the answering companies were visited. After considering these data and the information received (basis for the estimates in Table I), it is believed that the method employed for the survey can be considered successful.

B. Discussion of Suggested Needs

The following discussion is limited to items listed in Table I. When possible, an attempt has been made to give the volume potential for the raw material considered.

1. Oils

a. Drying Oils. Industrial processors and consumers have experienced supply difficulties with drying oils for a number of years. This has been attributed to international trade difficulties and to speculation on the world markets. Domestic production of linseed oil has indicated what can be done to alleviate dependence on foreign markets, and the advance in the development of a tung and castor oil industry in this country has been welcomed by drying oil consumers. These industries are looking forward to a stable domestic source to meet their drying oil needs.

(1) Dehydrated Castor Oil. The demand for dehydrated castor oil has increased steadily during the last few years since it has been difficult to obtain tung oil. Some of its drying properties are superior to those of linseed oil and they compare favorably with those of tung oil. It has been estimated that the present castor bean

program should lead to a crop of 78 million pounds per year of castor beans, for which a price of about six to seven cents per pound can be expected. This volume represents approximately 20 per cent of the total estimated 200 million pounds of castor oil needed by this country annually. Approximately 25 per cent of this total is needed as dehydrated castor oil for drying oil purposes. When the volume of beans which will be produced domestically is compared to the total volume requirements, it is evident that the deficiency must be met by imports or by expansion of the domestic program.

(2) Perilla Oil. Several industrial organizations in the protective coating field have expressed interest in a source of a perilla-type oil. The Far East at one time supplied the United States with perilla oil, but it has not been available from any source in recent years. Since it has been estimated that about 60 million pounds of this oil could be consumed annually in this country at the market price of linseed oil, the protective coating industry is awaiting the development of a domestic source for a drying oil of this type.

(3) Safflower Oil. This oil has recently attracted the attention of a number of organizations in several fields. This interest has been attributed to widespread experimentation with this oil. Its excellent color retention (non-yellowing upon drying) and other unique properties have led to the opinion that safflower oil will increase in importance in a number of processing industries. During 1950, approximately 50 thousand acres of safflower were planted in this country. This acreage yielded about 14 million pounds of seed, roughly equivalent to four million pounds of oil. Since the volume potential of safflower oil for all uses has been estimated at 60 million pounds per year at about

the price of linseed oil, it would appear that the continued development of this crop would be practical.

(4) Tung Oil. The fluctuating price and supply history of this oil has caused widespread interest in a domestic source of supply for an oil of this type. The supply from the Gulf Coast development so far has been small, and the general situation has been one of inadequate supply and prohibitive prices. The volume needed by this country for all uses is approximately 125 million pounds annually at a price about two cents per pound higher than that of linseed.

(5) Substitute Drying Oils. During the course of this survey, several plants have been suggested as possible sources of drying oils. Of these, the two which appear to be most interesting are Garcia nutans and Chia (Salvia hispanica). The seed from the pinchello tree (Garcia nutans), which is indigenous to Mexico, contains an oil similar to tung. Reports from the paint industry indicate that this oil could be substituted in tung oil formulations if it were available. The seed of Salvia hispanica yields an oil which has been reported to be a direct substitute for perilla oil. Some experimental work has been done with these plants. It is believed that additional work will be valuable and might lead to the development of a domestic source of supply for oils of the tung and perilla types.

b. Essential Oils. The United States is almost entirely dependent on foreign sources of supply of essential oils. The oils reported as being in short supply are numerous; the shortages in some cases are attributed to the effect of governmental price ceilings which reputedly restricted the profits of the importers. If the majority of the essential oils are

considered on a volume or monetary basis alone, they are of little economic significance. However, their widespread use and present demand has created interest in establishing domestic production of the source plants that can be adapted to economical growing and processing in this country.

There are several oils which have been considered because of their volume and industrial significance; these are oils of citronella, lemon-grass, lime, coriander, and anise.

(1) Oil of Citronella. Citronella has widespread uses as a starting material in the synthesis of organic compounds, one of which is menthol. The demand for oil of citronella has exceeded the supply in recent years, and an increase in price has been the result. This fluctuating price and supply history has caused concern among the large volume users of this material and has led to the desire for a domestic or more stable source.

The continued development of the Latin American production of the Java-type oil has been suggested as the answer to this problem. The volume potential for oil of citronella has been estimated at four million pounds per year if the price were reduced to about \$1.00 per pound.

(2) Oil of Lemon-Grass. This material has been reported as being in short supply periodically for a number of years. During the period 1949-1951 the supply was inadequate and the average import price varied from about \$1.30 per pound to \$3.15 per pound. The volume imported during this period averaged about 600,000 pounds per year, but increased demand from established and new uses increased the potential volume needed to approximately one million pounds per year. This volume is based on a price of about \$1.30 per pound for oil of lemon-grass.

The production of lemon-grass flourished in Florida during World War II when the price of the oil was about \$4.00 per pound. Consumers were very pleased with the uniform quality of the domestic material. For this reason, and because of its fluctuating price history, some users have expressed interest in the development of a domestic source on an economic basis comparable to that of the imported material.

(3) Oil of Lime. An increase in demand with a decrease in supply has almost doubled the price of this material in the last two years. Volume requirements have been estimated at 300,000 pounds per year at about \$4.00 per pound. Limes have been grown for the oil in this country, but the bulk of the material has been imported from Mexico and the Caribbean area. The problems involved with the importation of this item include the fluctuating price history mentioned above and the variation in quality of the product received; the consumers of this material would like to see a domestic production developed.

(4) Oil of Coriander and Oil of Anise. Several of the oils in the Umbelliferae family have been reported as being either in short supply or under foreign control. Of these, two of the most important on a volume basis are oil of coriander and oil of anise. Plants from which these oils are produced have been grown in the United States, and if domestic oils were available, they would find ready acceptance on the present market.

c. Other Oils.

(1) Coconut, Babassu, and Palm Kernel Oils. There is a definite need in the United States for lauric acid bearing oils, even though the supply throughout 1950 was reported as being adequate. Such oils are obtainable chiefly from the coconut palm of the Philippine

Islands, the babassu nut of Brazil, and the palm kernel from Africa. This country experienced great difficulty in obtaining oils of this type during World War II when the Philippines were under Japanese control, and changing political positions could cause a similar situation to arise again. The necessity for importing oils of this type has been considered by representatives of several industries as one of the gravest raw material problems of the United States. Coconut fatty acids have developed into a strategic material since they are used in the manufacture of Napalm, the excellent general purpose weapon of the military. This use of lauric acid oils, as well as the extension of its use in the detergent field, has increased the volume potential for this type material to about 850 million pounds per year.

(2) Palm Oil. The supply of palm oil has been below demand since 1949 by about 30 million pounds. Substitutes for some uses have been developed; nevertheless, the volume potential for palm oil has been approximated at 80 million pounds per year at about ten cents per pound.

(3) Sperm Whale Oil. Although this oil is not derived from a botanical source, it is considered here because of its strategic importance. The speculative nature of obtaining this material has led to considerable interest by industry in the possibility of developing a plant source for a substitute. Expeditions have to be financed far in advance of obtaining the oil with the consequent possibilities of loss either by storm or by a poor catch. Expeditions were not permitted during World War II, and the same situation has been visualized as a future possibility. Research on possible substitutes has been conducted, and the oil from Simmondsia seed has been found to be a suitable replacement.

If the volume required for the new uses which have been developed is included with the volume of sperm oil now needed, 45,000 tons per year has been estimated as the volume potential for Simmondsia-seed oil. This figure is based on an approximate price of \$225.00 per ton for the raw material. If Simmondsia seed could be developed as a crop, based on the above statistics it would represent an income of about 10 million dollars annually to the American farmer.

(4) Domestic Edible Oils. Some interest has been expressed in the development or expansion of a domestic source of such edible oils as olive, sesame, and sunflower. Domestic olive oil production meets only a fraction of the demand, and a decrease in importation in recent years has created a shortage of the material. The interest in sesame and sunflower oils has led to research with these plants. If difficulties of cultivation and harvesting can be overcome, these may become valuable additions to the domestic oil-producing crops.

2. Fibers

In recent years, the increase in demand for fibers has caused fiber-consuming industries in this country considerable difficulty. Production of some fibers has increased, and shortages have been seasonal, but in several cases there is a need for increased production of the materials or for suitable substitutes. Items of particular interest in this category are: cellulose fiber, "harsh" and long staple cotton, jute, and carpet wool. These materials, in general, are classed as large volume imports and international trade difficulties with these items could place this country in a difficult economic position.

a. Cellulose Fiber. The need for the so-called long cellulose fiber (greater than 2 mm.) for papermaking has been well known for a

number of years, but recent reductions in imports and expanding uses for cellulose have greatly disturbed the cellulose processing industries. Representatives of several organizations have expressed the desire for a domestic source of long cellulose fiber that would produce annually several times more fiber per acre than present sources. Faster growing trees and/or annual or perennial plantation-type crops have been suggested as solutions to the supply problem. Plants which have been suggested as fiber sources are bamboo and the so-called Japanese paste hemp. Considerable research has been done with bamboo fiber, and industry awaits future developments of the bamboo program of the United States Department of Agriculture. The Japanese paste hemp is unique in that the plant contains a mucilage which can be used as a deflocculation agent in papermaking.

b. Cotton. The so-called "harsh" cotton imported from India and Peru and the long staple cotton imported from the Mediterranean area have been reported as being in short supply. These items, like many other imports, are subject to the export controls of foreign countries. This factor and speculation on the world markets have been contributing causes for the fluctuating price histories of those commodities. Several companies have indicated an interest in domestic production of these types of cotton fibers. Volume potentials of about 28.5 million pounds per year at \$0.19 per pound for "harsh" cotton and 65 million pounds per year at \$0.45 per pound for the long staple indicate crops of appreciable monetary value.

c. Jute. The supply of jute and jute products has been considered inadequate by several segments of American industry. The import price of about \$0.19 per pound for jute during 1951 caused a shift to lower-priced substitutes for some uses, but new uses and the extension

in volume needed for established uses have maintained a high demand. Even if recent reports that the supply of jute should increase are true, it would be in error to consider this material solely on the economics of the situation. The likelihood of change in the political position of the producing countries must also be visualized. These factors, as well as the price picture, have led to interest in possible substitutes for jute. Research has indicated that kenaf is a potential replacement for a number of large volume uses, and industry would definitely like to see a domestic development of kenaf. The potential volume needed for a jute-type fiber has been estimated at 900 million pounds per year at about \$0.12 per pound.

d. Carpet Wool. The decrease in recent years of the world's production of wool has caused wool-consuming industries some difficulty. The carpet industry is interested in the domestic development of a replacement for carpet wool. Synthetic fibers have been employed for this purpose, but the supply of these materials has not been adequate. The carpet industry presently consumes about 250 million pounds of wool annually, but the supply of fibers for carpet making is about 80 million pounds below the demand.

e. Other Fibers. Interest has been expressed in the domestic development of several other types of fibers; included are ramie, hard fibers such as sisal, and an organic fiber which would lend itself to flame-proofing and thus could be used as a replacement for asbestos. Expansion of the Latin American development of hard fibers should aid in meeting the demand for the sisal-type material. Ramie has been used for several industrial purposes, but the availability and price have not been satisfactory. From the technological standpoint, a desire has been

expressed for strains of ramie which would be more frost resistant and would be characterized by a minimum branching tendency, large stalk diameters, and naturally recurring convolutions which would aid in spinning. Spokesmen for the asbestos textile industry believe that an organic fiber that would lend itself to flame proofing might be used as a replacement for chrysotile fibers in asbestos products which are not required to meet Underwriters' grade. This substitution could free the long chrysotile fiber now being used for asbestos tile, paper, etc., for use as raw material for producing needed asbestos textiles.

3. Drugs and Pharmaceuticals

The United States is almost entirely dependent on imports for its drug and pharmaceutical raw materials. This condition permits speculation by foreign interests and places the drug manufacturers in this country at an economic disadvantage. During periods of international difficulty, the supply is often cut off; this could place the health and welfare of the people in jeopardy. With these factors in mind, representatives of several organizations have recommended the stockpiling of botanical drug plants in the form of nucleus plantings of specimens that can be grown in the United States. Such plants would serve as a potential source of pharmaceutical raw materials which could be expanded during periods of international difficulty.

a. Belladonna. The present supply of atropine, the main alkaloid found in the roots and leaves of the belladonna plant, has been reported as inadequate by a number of industrial organizations. The volume of belladonna imported into this country in 1950 was approximately 357,000 pounds, at a price of about \$0.27 per pound. This volume was considered adequate and the price considered reasonable. The present requirements have been estimated at 360,000 pounds per year.

b. Ergot. In recent months the short supply of ergot has placed this material in the critically short category. The United States is almost entirely dependent on foreign sources for this item. In past years imports have come from Spain, Portugal, and Russia and her satellite countries. In recent years the supply has come principally from Spain and Portugal, but recent crop failures in these countries have virtually cut off all sources of supply. The University of Florida has recently announced that the chemical concentrates of a species of mushroom, Clitocybe subilludens, resemble ergot in some of their physiological reactions. These data, along with the fact that ergotamine and ergonovine have been isolated from the mushroom, have led to considerable interest by industry in its commercial possibilities. The task of administering the commercial development of the Florida process has been assigned to an industrial organization. Information as to the progress of the development is not available at present. The estimated volume requirements for ergot are approximately 250,000 pounds per year, and with the ever increasing need for the several alkaloids which it contains, the potential has been approximated at 600,000 pounds per year.

c. Menthol. The present market price of about \$9.50 per pound has forced several industrial organizations to place menthol in the prohibitive price category. This price has also caused a shift to the synthetic material by some users. However, there are several uses in which synthetic material has been unable to meet the performance of the natural menthol. This factor and the fluctuating price and supply history have caused the processors of menthol to become interested in an established domestic source of supply. The present volume requirements have been estimated at 600,000 pounds per year at about \$8.50 per pound. However,

representatives of several organizations have indicated that a domestic production should be based on a raw material selling price of about \$5.00 per pound.

d. Psyllium Seed (Plantago ovata). The husk of the Plantago ovata seed has been used for a number of years in the formulations of bulk laxative preparations. The demand for this material has increased the quantity of seed required for this purpose to about 4,250,000 pounds of seed per year. One organization has indicated that experimental work with this seed has disclosed several industrial applications which are based on the unique gelatinous properties of the husk. It has been estimated that the starting potential for the seed for these new uses would be about six million pounds annually if the 1950 import price were reduced by 60 per cent. This potential might be increased over a period of five to ten years to approximately 25 million pounds per year. The political unrest in India, the principal supply source of ovata, and this estimated potential have activated experimentation by two organizations as to the feasibility of domestic cultivation of Plantago ovata. Much of this work has been done in Arizona. Results thus far have indicated relatively low yields and high cost per acre. If the research programs, which included breeding, cultivation, and harvesting, provide the solutions to several problems, this plant might develop into a crop of value to industry and agriculture.

e. Papain. It has been reported by several organizations that papain, the proteolytic enzyme from the juice of the fruit and leaves of Carica papaya, is in short supply. This material has been used as a digestive aid and as an anticlouding agent in beer. The present volume requirement has been estimated at 500,000 pounds per year at a price of

from \$1.60 to \$2.00 per pound. The estimated volume potential has been placed at approximately one million pounds per year at about \$1.50 per pound. This is based on the extension of present usage and on new uses, one of which is a new powder for tenderizing meat in the home. Since papain is an imported item which is often contaminated with diluents, the users of this material are interested in a domestic source not only for a stable supply, but also for a supply with a stable purity. Ficin, an enzyme found in the fig, has been reported to be a substitute for papain for some uses and has been recommended as a proteolytic enzyme source that should be investigated.

f. Other Drugs. Three other materials which have been reported as needed are: khellin, cortisone, and steroids for starting materials in hormone synthesis.

Khellin is extracted from the fruit of the plant, Ammi visnaga, which is indigenous to North Africa. The Egyptian government at present holds a monopoly on the supply of this drug, which has been established as useful to relieve hypertension and to relax the so-called smooth muscles of the body. The extension of khellin into the treatment of asthma and other pulmonary diseases has been restricted, since all available supplies are going to the retail market. The present retail sales of khellin preparations have been approximated at five million dollars per year. It has been estimated that this figure could be increased tenfold if the material were available. The research on the secondary constituent of Ammi visnaga and on new uses of khellin has been discontinued by several organizations since the present supply of material cannot meet the present demand, much less the demand of new uses.

An adequate source of supply of the hormone, cortisone, is considered by a number of large pharmaceutical organizations as the most important drug need of the United States. This interest has led to extensive work on possible sources by several organizations. A by-product of this work has been a stimulated interest by industry in the steroid field which should lead to the development of a more extensive steroid industry.

Several plants have been suggested that are reported to be sources of materials that are useful in the treatment of specific maladies. Among these are: Oplopanax horridus (Fatsia horrida), Stephania cephalantha, and Stephania sasakii. Oplopanax horridus is reported as having possibilities as a source for an antidiabetic agent. Interest has been expressed in a readily available, inexpensive source of this plant since considerably more research could be performed with the material to the probable advantage of numerous diabetics. Materials contained in Stephania cephalantha and S. sasakii have been reported as useful in the treatment of tuberculosis and leprosy. A large pharmaceutical organization is investigating these plants to determine their scientific and economic values.

4. Waxes, Gums, and Resins.

The United States is almost entirely dependent on foreign sources for the supply of materials in these categories. Many critical uses for these materials exist in the present industrial structure; consequently, they are of concern to processors in several industries. These industries are considered to be at an economic disadvantage, since they are usually at the mercy of foreign exporters. Several of the major items are subject to supply and price control by the producing countries,

and contamination or dilution of the materials is the general practice. These conditions have led to a widespread desire for a stable domestic source of gums and waxes.

a. Candelilla. This wax is usually imported from Mexico. It has several uses, one of which is as a diluent or extender for carnauba wax. The increase in price of carnauba has increased the demand for this material. The volume imported into this country has increased from about two and one-half million pounds in 1939 to about five and one-half million pounds in 1950. The estimated potential for this wax has been placed at eight million pounds per year at the 1950 price of about \$0.40 per pound. A spokesman for the wax industry has indicated a general interest by the industry in a domestic source, primarily to ensure a stable purity and price.

b. Carnauba Wax. The entire wax-using industry is interested in a domestic source of a true substitute for carnauba wax. This has been brought about by the Brazilian control of the market and by the adulteration of the material received in this country. Such a development would be of considerable value, since annual imports of carnauba are of the order of 20,000,000 pounds per year at about \$0.75 per pound. Investigations of the possibility of developing domestic carnauba production and substitutes for this material have been recommended by several major consumers as research projects worthy of consideration.

c. Hydrogenated Simmondsia Oil. This material has been suggested as a useful wax. It is a hard, crystalline, white wax with a melting point only slightly lower than that of carnauba. It has many applications in the wax-using industries and undoubtedly would be used if it were available at a price comparable with candelilla wax.

d. Karaya Gum. Several industries are concerned about the supply of gum karaya. This material is widely used in the paper, textile, and pharmaceutical industries and is considered to be a strategic item. The indefinite political position of India, the principal source of karaya, and the increasing import price have led to a desire for a substitute or domestic source of this material. A volume potential of about 10,000,000 pounds per year, at about \$0.20 per pound, has been estimated for karaya gum.

e. Locust Bean Gum. The importation of this material has continually increased over the past 15 years from about three million pounds per year to approximately 11 million pounds per year. The import price has increased during this period from \$0.12 per pound to about \$0.32 per pound. Locust bean gum has a wide variety of uses that extend from the food preparation to the paper-making industries. The volume potential for a similar gum for paper making alone has been estimated at 22,000 tons per year if the selling price in this country were reduced to \$0.20 per pound.

Guar, another gum of this type, has been substituted for locust bean gum for some uses. Interest has been expressed in the continuation of the domestic development of this material.

f. Gum Tragacanth. The supply of gum tragacanth has been considered inadequate since 1946. This fact and the prohibitive price have forced users of this material to search for lower-priced substitutes. Locust bean gum has met the requirements for several of the uses for which tragacanth has been employed, but some companies have been unable to find an adequate substitute for other uses. The volume potential

for tragacanth would be about three and one-half million pounds per year if the material were available.

g. Latex. The need for a domestic source of latex has been established for a number of years. The development of synthetic rubber alleviated this need to a large degree, but there is still widespread interest in the natural product for some uses. The research done on this problem has been voluminous, and results in some cases have been promising. Representatives of several industrial organizations have indicated that they are awaiting the development of a domestic source for latex. Material produced domestically will find a ready market if the grade and price are compatible with those of present sources.

5. Miscellaneous Materials

a. Bristles (Hog). In recent years the volume of hog bristles imported for use in industrial brushes has been below the demand. The resulting price (as high as \$1.50 per pound for some material) has led to the substitution of synthetic materials for many uses, but satisfactory substitutes have not been found for use in paint brushes and other similar products. Representatives of industrial organizations have expressed the need for a domestically produced organic fiber that could meet the specifications for paint brushes. The estimated volume needed for brush bristles is about eight million pounds annually at about \$3.50 per pound.

b. Cork. Although cork has been in short supply during certain periods in the past, it is reported as being readily available at the present. However, the price has increased to a point where it may be prohibitive to use it for some products. The price picture and the continually dropping grade of the material imported have led to interest by industry

in a suitable substitute. In past years one organization gave some consideration to these problems and tried to institute a program to grow cork domestically. The results of preliminary phases of this program indicated that the project was beyond the scope of any individual corporation and that the problems involved in building a domestic cork industry could be more adequately handled by the Federal Government.

c. Pyrethrum and Other Insecticides. The demand has been greater for pyrethrum in recent years, and production has not increased in sufficient proportion to satisfy this demand. This has resulted in a shortage of this material. The present volume of pyrethrum flowers needed has been estimated at 12 million pounds per year at about \$0.30 per pound. This volume requirement could be changed by the recently introduced allethrin; the producers of allethrin believe that they will be able to take care of a considerable portion of the pyrethrum demands by 1953.

Several other insecticides have been reported as being in short supply; these are rotenone, ryania, and sabadilla. In general these materials are not all-purpose insecticides but are almost irreplaceable for specific uses. Interest has been expressed in the domestic development of imported plants or of plants containing these materials which are indigenous to this country. Some interest has been expressed in the new material, scabrin, and additional industrial research in general is contingent on a more readily available supply of the material.

d. Tannin, Pepper, and Zein. Other items that have been considered in short supply are tannin, pepper, and zein. The need for a domestic source of tannin to replace the almost defunct chestnut tree source has been established for a number of years. Sources should be

developed as emergency stand-bys even if they are economically incompatible with imports. Sources suggested are the cascalote bean, the palo blanco bark of Mexico and the Southwest, and sumac.

Diminished sources of supply and the continual demand have greatly increased the price of black pepper. An adequate substitute for this material would find a ready market since the supply has been estimated at 10 million pounds per year below demand.

The fiber made from zein has been accepted by industry, and expansion for this use and for new uses would take place if the material were more readily available.

VI. CONCLUSIONS AND RECOMMENDATIONS

The methods used for the survey have been considered satisfactory. Emphasis should be given to personal interviews with industrial leaders for subsequent surveys of this type.

The information reported indicates that the raw material needs can be classified into the following categories:

1. Oils
2. Fibers
3. Drugs and Pharmaceuticals
4. Waxes, Gums, and Resins
5. Miscellaneous Materials

The data indicate the most critical needs to be fibers (such as cellulose, jute, and "harsh" cotton), oils, and several drugs (such as ergot and atropine). Most of the items listed as needs have been so classified by organizations because of deficient supplies or prices which are incompatible with the present price structure. Domestic sources have been recommended for several items because, among other

undesirable conditions, there is frequent contamination or adulteration of the imported materials.

Conclusions and recommendations for future work will be presented in the final report, but the extensive information obtained in the course of this phase of the survey indicates that the continuation of this work would be valuable to the Sponsor.

Respectfully submitted,

H. V. H. Sineath,
Assistant Project Director

Approved:

Herschel H. Cudd,
Project Director

Gerald A. Rosselot, Director
State Engineering Experiment Station

VII. APPENDIX

The following is a copy of the text of the letter sent to individual companies:

Dear :

As you know, the Bureau of Plant Industry of the U.S. Department of Agriculture has a division of Plant Exploration and Introduction. One of its missions is the discovery and introduction of new plants into this country. In order to give them an indication of which types of plants to "hit the hardest" in their research program, we have been commissioned by the Bureau to attempt to compile the long-range raw material needs or desires of industry; that is, specific items by name and specification which are, or will be, in short supply. We are also interested in raw materials for which substitutes or cheaper sources are desirable. This includes materials whose supply would be affected by international trade difficulties.

Specifically, we are requesting that you forward information known to you or your associates of any raw material shortages or needs which now exist or which are anticipated in the future.

We are interested in either an affirmative or a negative response; however, in the event that you are able to suggest needs, we would welcome the opportunity of meeting with you or representatives of the organization. If you are unable to suggest such needs, is it possible that you could refer us to someone in your field who might have information of this type?

We will appreciate your consideration of this matter and will look forward to hearing from you.

Yours very truly,

H. H. Sineath

TABLE IV

ITEMS SUGGESTED WHICH HAVE NOT
BEEN CONSIDERED IN THE REPORT

Item	Item
<u>Drying Oils</u>	<u>Essential Oils (Continued)</u>
1. Hempseed Oil	21. Oil of Lavender
2. Linseed Oil	22. Oil of Licorice
3. Oiticica Oil	23. Oil of Marjoram
4. Soya-Bean Oil	24. Oil of Mustard Seed
5. Walnut Oil	25. Oil of <u>Ocotea cymbarum</u>
<u>Essential Oils</u>	26. Oil of Parsley Seed
6. Angelica Root and Seed	27. Oil of Patchouly
7. Bergamot	28. Oil of Pepper
8. Bois de Rose	29. Oil of Peppermint
9. French Oil of Bitter Almonds	30. Oil of Pine Needle
10. Oil of Birch Tar	31. Oil of Rose
11. Oil of Calamus Root	32. Oil of Rosemary
12. Oil of Caraway	33. Oil of Sandalwood
13. Oil of Cassia	34. Oil of Sassafras
14. Oil of Celery	35. Oil of Spearmint
15. Oil of Clary Sage	36. Oil of Thyme
16. Oil of Clove	37. Oil of Valerian
17. Oil of Clove Leaf	38. Oil of Vetiver
18. Oil of Dillseed	39. Oil of Ylang-Ylang
19. Oil of Geranium	40. Petit Grain Oil
20. Oil of Juniper Berries	

(Continued)

TABLE IV (Continued)

ITEMS SUGGESTED WHICH HAVE NOT
BEEN CONSIDERED IN THE REPORT

Item	Item
<u>Other Oils</u>	<u>Drugs and Pharmaceuticals</u>
41. Almond Oil	59. Aloes
42. Cohune-Nut Oil	60. Cascara Sagrada
43. Corn Oil	61. Camphor
44. Cottonseed Oil	62. Chamomile
45. Lupine Oil	63. Chinese Rhubarb
46. Peanut Oil	64. Cinchona Bark
47. Pine Oil	65. <u>Colchicum autumnale</u> Seed
48. Pine-Tar Oil	66. Datura
49. Poppy-Seed Oil	67. Dicumarol
50. Rapeseed Oil	68. Digitalis
51. Rice-Bran Oil	69. <u>Hyoscyamus</u> (Henbane)
52. Tall Oil	70. Ipecac
53. Teaseed Oil	71. Kamala
54. Ucauba Oil	72. Non-Mercurial Diuretics
<u>Fibers</u>	73. Opium
55. Cotton Lint	74. Quinine
56. Fibers for Felt-Making	75. Santonin
57. Hemp	76. Theobromine
58. Linen and Flax	77. Tocopherol

(Continued)

TABLE IV (Continued)

ITEMS SUGGESTED WHICH HAVE NOT
BEEN CONSIDERED IN THE REPORT

<u>Item</u>	<u>Item</u>
<u>Drugs and Pharmaceuticals (Cont'd.)</u>	<u>Waxes, Gums, and Resins (Cont'd.)</u>
78. Veratrum Compounds	96. Starch
79. Wormseed Oil	97. Tara Gum
<u>Waxes, Gums, and Resins</u>	<u>Miscellaneous Materials</u>
80. Alcohol Soluble Fats	98. Acids (5-9 Carbons)
81. Balata	99. Alcohols
82. Balsam of Peru	100. Alpha Protein
83. Balsam of Tolu	101. Barley
84. Congo Copals	102. Capsicum Pepper
85. Cumar-Type Resins	103. Cellophane
86. Dextrine	104. Chicory
87. Ghatti Gum	105. Cocoa Beans
88. Gum Acaroides	106. Cutch
89. Gum Arabic	107. Diglycol Stearate
90. Gum Benzoin	108. Ethyl Alcohol
91. Gutta Percha Gum	109. Ethyl Cellulose
92. Japan Wax	110. Fructose
93. Kelco Gum	111. Furfural
94. Rosin	112. Furfuraldehyde
95. Shellac	113. Fustic Extract

(Concluded)

TABLE IV (Concluded)

ITEMS SUGGESTED WHICH HAVE NOT
BEEN CONSIDERED IN THE REPORT

Item	Item
<u>Miscellaneous Materials (Cont'd.)</u>	<u>Miscellaneous Materials (Cont'd.)</u>
114. Gambier	127. Oleic Acid
115. Garlic	128. Quebracho
116. Ginger	129. Sage
117. Glycerine	130. Soap Bark
118. Glycerine Mono-oleate	131. Sorbitol
119. Glycol Mono-oleate	132. Soy Meal
120. Hydrostearic Acid	133. Spices
121. Java Nuntok	134. Stearic Acid
122. Lactic Acid	135. Tapioca Starch
123. Lecithin	136. Tonka Beans
124. Logwood	137. Turpentine
125. Molasses	138. Vanilla Bean
126. Nicotine	139. Wood Flour
	140. Wood